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ORIGINAL ARTICLES.

I.—*Mastodon* in the Pleistocene of South Africa.

By Professor Dr. Richard Beck, Freiberg.

LAST Summer, when I travelled in South Africa with the British Association, I examined the diamantiferous gravels on the Vaal River near Kimberley. During this visit Mr. Krumbelt, apothecary in Barkly West, had the kindness to give me three fossil teeth which he had found in the local gravels. Nos. 1 and 2 were obtained from the so-called breakwater workings of the river-side, while No. 3 was found in the Waldeck Plant in the higher terrace of gravels at an elevation of 60 to 80 feet. The state of preservation of all these teeth is that of real fossil remains.

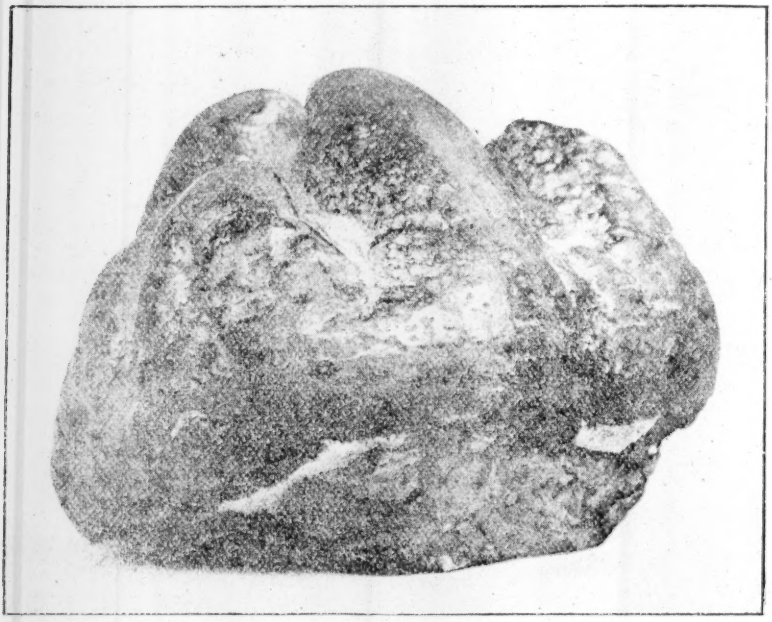
Mr. G. A. Boulenger was kind enough to compare the teeth numbered 1 and 2 with recent specimens in the British Museum, and communicated to me his determinations as follows:—

No. 1 is a molar of *Equus*, perhaps of a Zebroid species, as inferred from the locality.

No. 2 is a lower canine of a young *Hippopotamus*.

Tooth No. 3 is of much more interest, for, according to an examination kindly made by my friend Dr. Johannes Felix, Professor of Palæontology in Leipzic, it is a fragmentary molar of *Mastodon* (subdivision *Bunolophodon*). A determination of the species is impossible because the fragment is not sufficiently complete; but, as shown by the accompanying photograph of the fossil (Fig. 1), there can be no doubt as to its generic relationship.

The existence of *Mastodon* in South Africa, hitherto unknown, is of great importance for geology and biology. According to the latest memoir on the subject,[1] the younger Tertiary beds of Egypt,



Portion of unworn tooth of a *Mastodon* (subdivision *Bunolophodon*) from the Pleistocene, Waldeck Plant, higher terrace of gravels (60 to 80 feet) above the Vaal River, near Kimberley, South Africa.

Tunis, and Algeria have afforded the only African *Mastodons*. Now we are able to record this extinct Proboscidian from the Pleistocene of the far south of the Continent.

II.—On a Collection of Fossil Corals from Eastern Egypt, Abu Roash, and Sinai.

By J. W. Gregory, D.Sc., F.R.S., F.G.S.,
Professor of Geology, Glasgow University.

(PLATES VI and VII.[2])

THE corals described in this report were collected by members of the Egyptian Geological Survey, and were sent to London in September, 1899. I then examined most of the specimens, and submitted a preliminary report to the effect that they belong to three horizons:—

[1] Depéret, "Découverte du *Mastodon angustidens* dans l'étage carténnien de Kabylie": Bull. Soc. Géol. France, vol. xxv (1897), pp. 518–521 and plate.

[2] Plate VII will appear with the second part of paper in the March Number.

(1) The Cretaceous limestones of Abu Roash.
(2) A series of Pleistocene reefs on both shores of the Gulf of Suez, of which the corals have solely Red Sea affinities, and show no greater trace of the influence of intermixture with the Mediterranean fauna than is shown by the living corals of the Red Sea.
(3) A series of older corals, which show some points of resemblance to the existing Red Sea coral fauna, but are decidedly of pre-Pleistocene age; but as the sections of some of these corals were not ready when my preliminary report was closed, I could not express a final conclusion as to whether they were of Miocene or Pliocene age.

The completion of this report was sadly delayed, owing to the heavy pressure of work in Australia; and I am very grateful to Captain Lyons, the Director of the Egyptian Survey, for the consideration with which he has allowed me to retain the material for so long.

The full examination of the material, with the aid of sections, confirms the opinion formed from my preliminary inspection. The bulk of the material is of Pleistocene, and apparently late Pleistocene age. This conclusion is in agreement with Mr. R. B. Newton's long list of fossil mollusca from the same localities. The specimens from Jebel Mellaha, and most of those from Abu Sha'ar, are Miocene; but one specimen reported as from Abu Sha'ar appears indistinguishable from a living variety of a Red Sea species —*Acanthastræa hirsuta*, var. *megalostoma*, Klunz. This specimen was the first from Abu Sha'ar which I had examined, and thus I was first led to the view that the limestones of that locality were Pleistocene. But when sections of the other specimens from that locality were available, they all proved to be of Miocene age. Either this one species has an abnormally long life or there is some error in the localization of the specimen.

The Miocene coral fauna resembles that of the Miocene of the Mediterranean and of Sind, and it lacks several of the commonest of the modern genera of Red Sea corals, e.g. *Madrepora* and *Stylophora*.

The geology of the area is described in Messrs. Hume & Barron's valuable memoir, "Topography and Geology of the Eastern Desert of Egypt" (Cairo, 1902).

A previous collection was described in the Geol. Mag., Dec. IV, Vol. V, 1898, pp. 241–251, Pls. VIII and IX.

I. CRETACEOUS.

Smilotrochus (?) sp.

There is one specimen (No. 3795) from the eastern end of the Abu Roash village, which appears to me to belong to this genus, but I cannot recognize the septal structure, as the specimen has been so greatly altered; the chances that a thin slice would show the internal characters do not seem to me to justify the injury that would be caused to the specimen. It is figured (Pl. VI, Fig. 1) in the hope of the discovery of fresh material.

II. MIOCENE.

FAVIA, Oken, 1815.

FAVIA HUMEI, n.sp. (Pl. VI, Fig. 2.)

Diagnosis.—Corallum massive; surface subplane. Compact and dense in texture, with the exotheca well developed in horizontal, platform-like layers.

Corallites mostly elliptical and deformed; rarely circular. Their diameter is small. Corallites crowded, but the calicular edges are separated by well-marked furrows, 1–1½ mm. across.

Septa, 3 complete cycles; an incomplete fourth cycle may be present. Paliform lobes indistinct.

Calices shallow.

Dimensions.—The fragment of corallum measures:—

Length	80 mm.
Width	56 ,,
Thickness	45 ,,

Corallites:—

Diameter	3 or 4 mm. wide, by 4½ mm. long.

Calicinal centres:—

Distance	5–6 mm.

Distribution.—Miocene. From Reef No. 2, plateau between Camps 27 and 28, Wadi Belih, Abu Sha'ar. Collected by Mr. T. Barron, H 1780.

Figures.—Pl. VI, Fig. 2, part of the surface of the corallum, by 1½ diameter.

Affinities.—This species is easily distinguished from those that most nearly resemble it, by the small size of the corallites. Its nearest ally seems to me to be *F. savignyi*, Ed. & H.,[1] in which the calices are 12–15 mm. wide and 4–5 mm. deep.

Favia corollaris (Reuss)[2] has corallites from 7 to 8·5 mm. in diameter, and they are more constantly circular in form.

ORBICELLA, Dana, 1848.

1. ORBICELLA MELLAHICA,[3] n.sp. (Pl. VI, Figs. 3 and 4.)

Diagnosis.—Corallum large, massive, with subplane upper surface, which is ornamented by the slightly raised calicinal borders; by the long and often confluent costæ, between which are occasional large granules.

Corallites long, circular, or elliptical; diameter from 4–5 mm. Walls of medium strength, being about half a millimetre in thickness. Calices very shallow in well-preserved corallites; borders low. Septa 3 cycles, with an occasional rudimentary septum of a fourth cycle in the largest corallites. In larger corallites, with the best

[1] Edwards & Haime: Hist. nat. Cor., vol. ii, p. 437.

[2] Von Reuss, Kor. ost. ung. Mioc.: Denk. Akad. Wiss. Wien, vol. xxxi (1872), p. 238, pl. xii, fig. 3.

[3] After Jebel Mellaha, the locality of the type-specimen.

developed columella, the septa of the first and second cycles reach the columella. Exotheca coarsely vesicular, abundant.

Columella well developed.

Dimensions :—

	Type-specimen (a fragment of a much larger mass) H 1862.	H 1856.
Length	128 mm.	155 mm.
Width	75 ,,	120 ,,
Thickness	40 ,,	95 ,,
Corallites :—		
Diameter ...	4 mm., occasionally 5 ,,	4 ,,
Calicinal centres :—		
Distance ...	6–9 mm., average 7 ,,	5 and 7 mm.

Distribution.—Miocene. West flank of Jebel Mellaha, H 1862; H 1856. Reef No. 2, plateau between Camps 27 and 28, Wadi Belih, Abu Sha'ar, H 1818*b*. "Beach Plateau," Abu Sha'ar, H 1780*a*.

Figures.—Pl. VI, Fig. 3, part of the surface of H 1862, by 1½ diam. Fig. 4, some corallites of H 1818*b*, by 2 diam.

Affinities.—This species is a typical *Orbicella* with corallites of medium size. It is nearest to *O. defrancei* (Ed. & H.)[1] from the Miocene of Bordeaux, Turin, and Asia Minor. But it differs as the corallites are much smaller, having an average of 4½ mm. in diameter instead of 6–7 mm., and in most cases the corallites have only 3 cycles of septa. *O. defrancei* has a fourth cycle, sometimes incomplete; but *O. mellahica* has 3 cycles with an occasional corallite with a rudiment of the fourth. In *O. humphreysi*, Felix,[2] the diameter of the calices is only 2·5 to 3 mm.

It differs from *O. schweinfurthi*, Felix,[3] in the same characters as those whereby it differs from *O. defrancei*.

Of the three Miocene *Orbicellæ* from Sind described by Duncan, it is nearest to *O. digitata*, Dunc.,[4] which has smaller calices and a smaller columella, and an average distance between the calicinal centres of only 4 mm.

2. Orbicella schweinfurthi (Felix), 1884. (Pl. VI, Fig. 5.)

Heliastræa schweinfurthi, Felix, 1884, Kor. ägypt. Tert.: Zeit. deut. geol. Ges., vol. xxxvi, p. 449, pl. v, fig. 5.

Orbicella schweinfurthi, Gregory, 1898, Egypt. Foss. Madrep.: Geol. Mag., Dec. IV, Vol. V, p. 246, Pl. IX, Fig. 3.

Distribution.—Miocene: Wadi Ramlieh (Felix); north side of Jebel Attaka, near Suez (Gregory); west flank of Jebel Mellaha, H 1862; "Beach Plateau," Wadi Belih, H 1782; "Beach Plateau," Abu Sha'ar, H 1818.

[1] Edwards & Haime: Ann. Sci. nat., ser. III, vol. xii (1850), p. 106; Hist. nat. Cor., vol. ii, p. 465.

[2] Felix, Stud. tert. und quart. Kor. ägypt. und Sinaihalbinsel: Zeit. deut. geol. Ges., vol. lvi (1904), p. 171, pl. x, fig. 2.

[3] Felix, Korallen ägypt. Tert.: Zeit. deut. geol. Ges., vol. xxxvi, p. 449, pl. v, fig. 5.

[4] P. M. Duncan, Mon. Foss. Corals and Alcyonaria of Sind: Pal. Ind., ser. XIV (1880), pp. 90–91, pl. xxi, figs. 7–8.

Figure.—Pl. VI, Fig. 5, a few corallites of H 1862, nat. size.

This species is a very close ally of *O. defrancei* (Ed. & H.), from which it differs by the walls of the corallites being thinner, and by having some of the exothecal dissepiments arranged concentrically like a second wall, as shown in a figure (Geol. Mag., 1898, Pl. IX, Fig. 3). This feature is well shown among the present collection by specimen No. H 1862, of which the corallites are figured on Pl. VI, Fig. 5.

3. Orbicella defrancei (Edwards & Haime), 1850. (Pl. VI, Fig. 6.)

Astrea defrancei, Edwards & Haime, 1850: Ann. Sci. nat., ser. III, vol. xii, p. 106.
Heliastrea defrancei, Edwards & Haime, 1857: Hist. nat. Cor., vol. ii, p. 465.
Heliastrea defrancei, Von Reuss, 1872, Kor. öst. ung. Mioc.: Denk. Akad. Wiss. Wien, vol. xxxi, p. 239, pl. ix, fig. 3; pl. x, fig. 1.
Orbicella cf. *defrancei*, Felix, 1904, Tert. quart. Kor. ägypt.: Zeit. deut. geol. Ges., vol. lvi, p. 172.

Distribution.—Miocene. France, Italy, Austria, Crete, and Asia Minor. Egypt, west flank of Jebel Mellaha, H 1862*b*; Abu Sha'ar, H 1768. East of Cairo (Felix).

Figures.—Pl. VI, Fig. 6, a few corallites from a transverse section, by $1\frac{1}{2}$ diameter. These show the relation of the species to its ally *O. schweinfurthi*.

SOLENASTRÆA (Edwards & Haime), 1848.

Solenastræa elliptica, n.sp. (Pl. VII, Fig. 11.)

Corallum large, massive; the corallites are long and cylindrical. Corallites extremely crowded. They are elliptical in section, separated by a narrow band of cellular exotheca, while on the surface the walls sometimes appear confluent. Calicular edges only slightly raised.

Septa, three complete cycles, of which the primary and secondary are subequal in size.

Columella very imperfectly developed; rudimentary in many corallites.

Dimensions.—The specimen is a fragment:—

Length	110 mm.
Width	82 ,,
Thickness	115 ,,
Corallites:	
Diameter	2 mm. by 1·25 ,,
Calicinal centres:	
Distance	2–3 ,,

Figures.—Pl. VII, Fig. 11*a*, part of the surface, by 2 diam.; Fig. 11*b*, part of a transverse section, by 4 diam.

Distribution.—Miocene: Abu Sha'ar, H 1818*a*.

Affinities.—This agrees very closely with *S. chalcidicum* (Forsk.) in the size of its corallites, the subequal size of the primary and secondary septa, and rudimentary development of the columella. It differs by the elliptical shape of the corallites, and the fact that the septa are larger and more conspicuous on the surface, and the

edges of the calices are less raised. It is allied to *S. turonensis* (Mich.),[1] from the Miocene of Turin, but that has rounded corallites. It differs markedly from *S. tenera* (Reuss),[2] its nearest ally in the Austrian Miocene, owing to the much greater distance between the corallites in that species; they are also more circular. I feel doubtful whether this species is not merely an elliptical variety of the recent Red Sea species, *S. chalcidicum* (Forsk.), of which a specimen from the raised reefs of Qosseir is shown on Pl. VII, Fig. 12. *S. anomala*, Felix,[3] from east of Cairo has round and crowded calices.

STYLINA, Lamarck, 1816.

Stylina tetramera, n.sp. (Pl. VI, Fig. 7.)

Corallum massive; upper surface subplane.

Corallites long and narrow; generally round and oval; crowded. The walls on the surface occur sometimes as sharp ridges, while in other parts they are separated by narrow depressions. Sections in the interior of the corallum show that the corallites are nearly always separated by interspaces crossed by some of the costæ.

Calices very deep.

Septa irregular; those of the first cycle very distinct; one series of septa is much more conspicuous than the other; and as this series often consists only of 4 or 5 septa, some corallites have a tetrameral aspect. This structure is less often noticed in sections through the interior of the corallum. There are two complete cycles, and the third cycle is usually incomplete.

Columella irregular. Seen from above it is conspicuous and joined to the 4, 5, or 6 largest septa, and it often projects into the calice as if it were styliform. Sections show that its structure is less regular; but a central styliform columella is often recognizable.

Dimensions.—Corallum :—

Length	160 mm.
Width	78 ,,
Thickness	80 ,,
Corallites :	
Average diameter	3 by 2 ,,
Calicinal centre :	
Average distance	3 ,,

Distribution.—Miocene: Plateau, Abu Sha'ar, H 1818.

Figures.—Pl. VI, Fig. 7, part of the surface of the corallum, by 2 diam.

Affinities.—This species is one of those that serve to link *Stylina* to the Orbicelloids, as it is in all respects a *Stylina* except that the columella shows a tendency to become trabecular.

[1] Michelin: Icon. Zooph., p. 312, pl. lxxv, figs. 1–2.

[2] *Explanaria tenera*, Reuss: Polyp. Wien. Tert., 1847, p. 18, pl. iii, fig. 2. *Solenastræa tenera*, Reuss, Kor. öst. ung. Mioc.: Denk. Akad. Wiss. Wien, vol. xxxi (1872), p. 242, pl. vii, fig. 5.

[3] Felix, op. cit.: Zeit. deut. geol. Ges., vol. lvi (1904), p. 173, pl. x, fig. 3.

The tetrameral arrangement reminds me of *Stylina fanjasi*, Ed. & H.,[1] but in that species the primary and secondary septa are equal.

LEPTASTRÆA, Edwards & Haime, 1848.

Leptastræa barroni, n.sp. (Pl. VI, Fig. 8.)

Diagnosis.—Corallum large and massive, with subplane upper surface; and the corallum is built up of long, narrow, cylindrical corallites; but on weathered edges, and in sections, it appears to be made of successive layers.

Corallites long and cylindrical; narrow; 2–3 mm. in diam., and often oval in section. On fresh surfaces the edges of the corallites are slightly raised. The walls, seen in section, are thin and connected by fine, vesicular exotheca. The corallites are close together, being separated by a very narrow band of exotheca, which is marked on the surface as a narrow groove around the calicular edges; but occasional calices are so crowded that the calicular edges are in contact.

Septa thin; they are long in the primary cycle; those of the secondary cycle may reach half-way to the axis, but in the interior they may reach the enlarged trabecular columella. The third cycle is little more than rudimentary. Primary septa exsert.

Columella appears as a small tubercle from the surface, but sections show that it is trabecular. It is of medium size, and then joins the two first cycles of septa.

Dimensions.—Corallum :—

Length	...	...	...	...	...	...	185 mm.
Width	...	...	...	...	...	...	155 ,,
Thickness	...	...	...	...	...	...	75 ,,
Corallites :—							
Diameter	...	...	...	...	...	...	2–3 ,,
Calicinal centre :—							
Average distance	...	...	...	...	...		3–3·5 ,,

Distribution.—Miocene: top of the Abu Sha'ar Plateau, west of the Red Sea, south-west of Jebel Zeit, H 1864.

Figures.—Pl. VI, Fig. 8*a*, part of surface, by 2 diam.; Fig. 8*b*, another part of the same specimen, by 2 diam.; Fig. 8*c*, section of interior of the same specimen, by 2 diam.

Affinities.—This coral is well preserved and its features are very distinct. The narrow diameter of its corallites gives it a close resemblance to *Plesiastræa*, but it has no pali. The coral which seems to be its nearest ally is the recent Red Sea coral, *Leptastræa bottai* (Ed. & H.),[2] which has a less conspicuous, less substyliform columella. *L. bottai*, moreover, may have a fourth cycle of septa, and its primary and secondary septa are described by Klunzinger as equal; and its corallites are from 3 to 4 mm. in diameter.

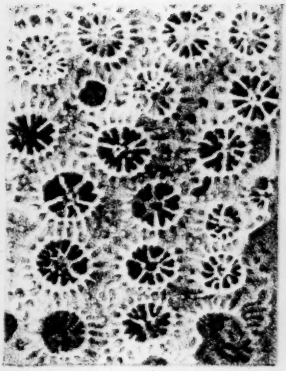
[1] Edwards & Haime: Hist. nat. Cor., vol. ii, p. 243.

[2] Edwards & Haime: Hist. nat. Cor., vol. ii, p. 486, pl. D7, fig. 1. Klunzinger: op. cit., pt. 3, p. 44, pl. v, fig. 9.

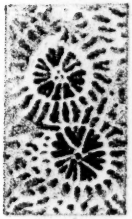
1a

1b

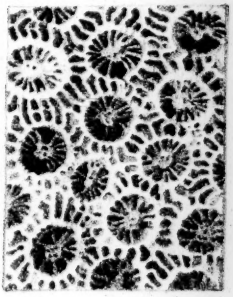
2 x1½



3 x1½



4 x2



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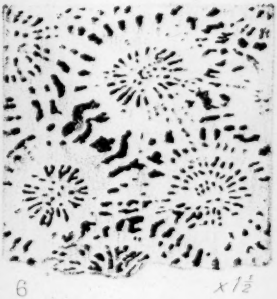
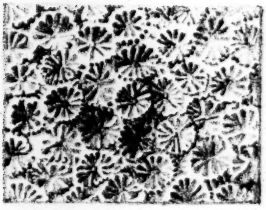
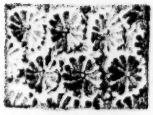


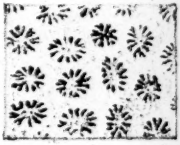
6 x1½



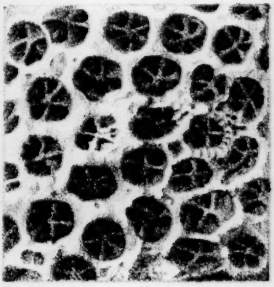
8a x2



8b x2



8c x2



7 x2

E. Drake del. et lith. West, Newman imp.

Fossil Corals from Eastern Egypt.
Fig. 1. Cretaceous. Figs. 2–8 Miocene.

ACANTHASTRÆA, Edwards & Haime, 1848.

Acanthastræa hirsuta, Ed. & H., 1850, var. megalostoma, Klunzinger.

Edwards & Haime, 1850: Ann. Sci. nat., ser. III, vol. xii, p. 145; 1857, Hist. nat. Cor., vol. ii, p. 502, pl. D 5, fig. 4.
Klunzinger, 1879: Korallth. roth. Meer., pt. iii, p. 42, pl. v, figs. 1–2.

Distribution. — Recent: Red Sea and Indian Ocean. Fossil, Pleistocene: Egypt (*fide* Edwards & Haime). Miocene: "Beach Plateau," Abu Sha'ar, H 1812.

I can recognize no specific distinction between this coral and the recent species, and it even appears to be referable to one of Klunzinger's two varieties of the species.

STYLOCŒNIA, Edwards & Haime, 1848.

Stylocœnia tuberculata, n.sp. (Pl. VII, Figs. 9*a*, *b*.)

Diagnosis. — Corallum massive, nodular, contracted below to a subpedunculate form; upper surface convex and well rounded.

Corallites about 2·5 mm. in diameter, very crowded, separated by thin, well-raised walls, with the angles raised as short, blunt tubercles. The tubercles, however, are low, and not always present, so that parts of the surface appear like *Astrocœnia*. Corallites polygonal to circular. Calice shallow.

Columella conspicuous, styliform, sometimes laterally compressed. Septa, 3 cycles; those of the first and second cycles are equal and reach the columella; those of the third cycle are much smaller.

Dimensions.—Corallum:—

Length	61 mm.
Width	40 ,,
Thickness	50 ,,
Corallites:—	
Diameter	2–3 ,,
Columella:—	
Diameter	about ·5–·6 ,,
Calicinal centres:—	
Average distance	3 ,,

Distribution. — Miocene: on plateau, 1,200 feet above sea-level, between Camps 27 and 28; Wadi Belih; eastern side of the Red Sea, to the south of Jebel Zeit. No. H 1814.

Figures.—Pl. VII, Fig. 9*a*, the corallum from the side, nat. size; Fig. 9*b*, part of the surface, by 2 diam.

Affinities.—In the absence of recorded species of *Stylocœnia* in Egypt it is natural first to compare this species with *Astrocœnia ægyptica*, Felix,[1] which appears to be a true *Astrocœnia*.

Its nearest ally appears to be *Stylocœnia vicaryi*, Haime, which has been well described and figured by Duncan[2]; his account shows

[1] J. Felix, Kor. ägypt. Tert.: Zeit. deut. geol. Ges., vol. xxxvi (1884), p. 438, pl. iv, figs. 5–6.
[2] P. M. Duncan: Mon. Foss. Corals and Alcyonaria of Sind, 1880, pp. 32–33, pl. xiii, figs. 4–7.

that the Indian coral has more rounded corallites, which are often separated by a well-marked furrow; the furrow is sometimes absent, and then the corallites become polygonal. The columella of *S. vicaryi* is also rounded.

PRIONASTRÆA, Edwards & Haime, 1848.

Prionastræa lyonsi, n.sp. (Pl. VII, Fig. 10.)

Diagnosis.—Corallum heavy, massive, with apparently subplane upper surface.

Calices apparently shallow.

Corallites large, average diameter of 16 mm.; polygonal and very crowded.

Septa coarse. An incomplete fourth cycle. Usually the primary and secondary cycles are united to the columella.

Columella large, but loosely trabecular, and not very well developed.

Walls inside the corallum are thin and inconspicuous.

Dimensions.—Corallum (fragment of a large corallum):—

	H 1814 A.	H 1812.
Length	110 mm.	... 120 mm.
Width	50 ,,	... 85 ,,
Thickness	75 ,,	... 130 ,,
Corallites:		
Diameter	16–17 ,,	
Calicinal centre:		
Distance	16–17 ,,	

Distribution.—Miocene: plateau, 1,200 feet above the sea, between Camps No. 27 and 28; Wadi Belih, H 1814*a*; plateau of Abu Sha'ar, H 1812.

Figures.—Pl. VII, Fig. 10*a*, part of worn surface of the corallum (of H 1814*a*) showing the rudimentary open columella, nat. size; Fig. 10*b*, part of thin section of the same specimen, nat. size.

Affinities.—The two nearest allies of this species appear to be *P. irregularis* (Defr.),[1] from the Miocene of Dax and Turin, which has the same general characters and very thin walls. But that species differs in that its corallites are only 10 mm. in diameter, and its septa are described by Milne Edwards & Haime as very thin. The nearest ally of *P. lyonsi* among living corals is *P. australiensis* (Ed. & H.),[2] which has corallites only 10 mm. diam. *P. tesserifera* (Ehrb.)[3] is the nearest of the living Red Sea species, and has corallites of the same size; but it has much thinner septa, and larger, more compact columella.

[1] *Astrea irregularis*, Defrance: Dict. Sci. nat., vol. xlii (1826), p. 381. *Prionastræa irregularis*, Edwards & Haime, 1850; and 1857, Hist. nat. Cor., vol. ii, p. 522.

[2] Edwards & Haime, 1857: op. cit., p. 520.

[3] *Astrea tesserifera*, Ehrenberg, 1834, Beitr. Corallenth.: Abh. k. Akad. Wiss. Berlin für 1832, p. 321. See Klunzinger, 1879, pt. iii, p. 37, pl. iv, fig. 9.

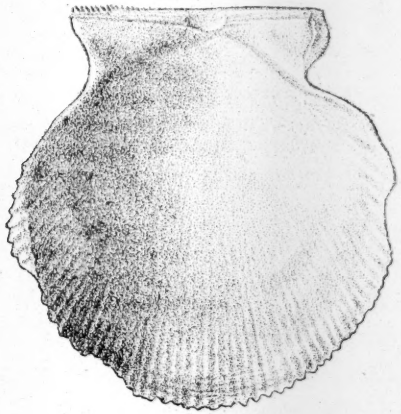
(*To be concluded in our next Number.*)

III.—Note on the Characters of the Hinge Plate in *Aviculopecten semicostatus*, Portlock, sp.

By Wheelton Hind, M.D., B.S., F.R.C.S., F.G.S.

MR. JOHN SMITH, of Kilwinning, has been fortunate enough to obtain from the Lower Limestone series of Auchenmade, Ayrshire, a specimen of the left valve of *Aviculopecten semicostatus*, Portlock, sp., which shows the hinge plate and interior most perfectly preserved. Hitherto a study of the hinge plate of *Aviculopecten* has been made from specimens which were merely casts of the interior, and consequently it has been impossible to observe that portion of the hinge plate immediately interior to the umbo. The Auchenmade specimen advances our knowledge of the anatomy of the genus, and establishes a character denied for it by its author, M'Coy.

We now know that *Aviculopecten* possessed a median cartilage pit, in the centre of the elongate, somewhat hollow, flattened hinge plate. The pit is comparatively large and transverse; the rest of the hinge plate is feebly striate longitudinally. Along the upper edge of the posterior part of the hinge-line is a row of erect tubercles.



Left valve of *Aviculopecten semicostatus*, Portl., sp., showing the hinge-plate and interior view of valve. Lower Limestone series, Auchenmade, Ayrshire.

The name *Aviculopecten* was given by M'Coy to those Palæozoic forms of *Pecten* in which the posterior ear was larger than the anterior, and the supposed absence of a mesial ligamentary pit in the hinge plate caused him to imagine that the affinity of the genus was structurally nearer to *Avicula* than *Pecten*. We now know that typical *Pecten* characters existed in Carboniferous times, and that *Aviculopecten*, as at present restricted, is very closely allied to *Pecten*, yet sufficiently distinct to merit a different generic name. M'Coy included *Pterinopecten* with *Aviculopecten*, but unfortunately we know very little about its hinge plate, only that of *P. rigidus* having been observed. There is no doubt of the propriety of Hall's subdivision of the Palæozoic Pectinidæ, one which I have adopted in my monograph on the British Carboniferous Lamellibranchs.

IV.—The Reptant Eleid Polyzoa.

By W. D. Lang, M.A., F.Z.S., F.G.S., of the British Museum (Natural History).

THE Eleidæ are a very natural family of extinct Polyzoa, remarkable for exhibiting characters relative to both the groups Cyclostomata and Cheilostomata. It is not, however, the affinities of this with other families that are here considered, but a means of determining by zoœcial characters the reptant 'species' within the group; the validity of the 'genera' forming it; the occurrence in England of one of the 'genera'—*Semimultelea*—hitherto unrecorded from Britain; the description of a new species of this 'genus'; and the phenomenon of local groups of zoœcia having characters differing from those of the rest of the zoarium.

The systematic position of the Eleids has been discussed by Gregory,[1] whose account of the group in the British Museum Catalogue this paper may be considered as summarising and as supplementing.

Before considering the points mentioned it will be convenient to tabulate the 'genera' of Eleids as at present established. As in the families of Cyclostomes, the Eleidæ fall into series founded on the habit of the whole colony (the zoarium). The general sequence is from single series of individuals to encrusting sheets, to foliate erect sheets, to erect cylindrical branches. The following table shows this sequence in the Eleidæ and in two families of Cyclostomes[2]:—

	Tubuliporidæ.	Clausidæ.	Eleidæ.	
			No avicularia.	With avicularia.
1. Encrusting zoarium composed of uniserial rows of individuals (zoœcia).	*Stomatopora.*	×	×	×
2. Encrusting zoarium composed of biserial to pauciserial rows of zoœcia.	*Proboscina.*	×	×	×
3. Encrusting multiserial zoarium composed of sheets (laminæ) of zoœcia. Unilaminar.	*Berenicea.*	*Cryptoglena.*	*Reptelea.*	*Reptoceritites.*
4. Encrusting zoarium of superimposed laminæ. Bilaminar-multilaminar.	*Reptomultisparsa.*	*Clausimultelea.*	*Semimultelea.*	*Reptomultelea.*
5. Erect bilaminar-multilaminar foliate zoarium.	*Diastopora.*	*Ditaxia.*	*Elea.*	×
6. Zoarium of unilaminar cylindrical branches.	*Entalophora.*	*Clausa.*	*Nodelea.*	*Meliceritites.*
7. Zoarium of multilaminar cylindrical branches.	×	*Multiclausa.*	*Multelea.*	*Inversaria.*

[1] J. W. Gregory: British Museum Catalogue of Cretaceous Bryozoa, vol. i (1899).

[2] See also for a small table of this kind, Gregory, British Museum Catalogue of Jurassic Bryozoa, 1896, p. 29.

This table shows that the Eleid 'genera' fall into two groups, those with avicularia and those without them. The former series has no term corresponding with *Elea* in the other series, that is, no erect foliate 'genus.' Both series are wanting in the more primitive types of zoarium, those that are encrusting and consist of zoœcia arranged either in single series or two or three abreast.

I. The Determination of Species and the Morphology of the Zoœcium.

The individuals (zoœcia) of an Eleid colony, exclusive of gonœcia and of gonocysts, may be of three kinds—

1. Normal zoœcia.
2. Avicularia.
3. Closed zoœcia.

In half the 'genera' avicularia are absent. Closed zoœcia only differ from normal zoœcia in the possession of a calcareous covering to the apertures. Therefore, it is only by means of the normal zoœcia that the specific characters of the whole family can be brought into line. For this purpose the characters of the aperture appear most useful on account of their variety and the ease with which they can be seen. The shape of the zoœcia, the character of their boundaries, and the frequency or rarity of the apertures vary so much in a single zoarium that they are of little use as specific indices. In one species at least, *Semimultelea acupunctata* (Novak), the character of the punctation of the front wall is used. Consideration of this character in the Jurassic forms of *Stomatopora* has led the author to consider that it is of little practical use in specific determination, because it is only clearly shown under favourable conditions of preservation or of subsequent weathering.[1]

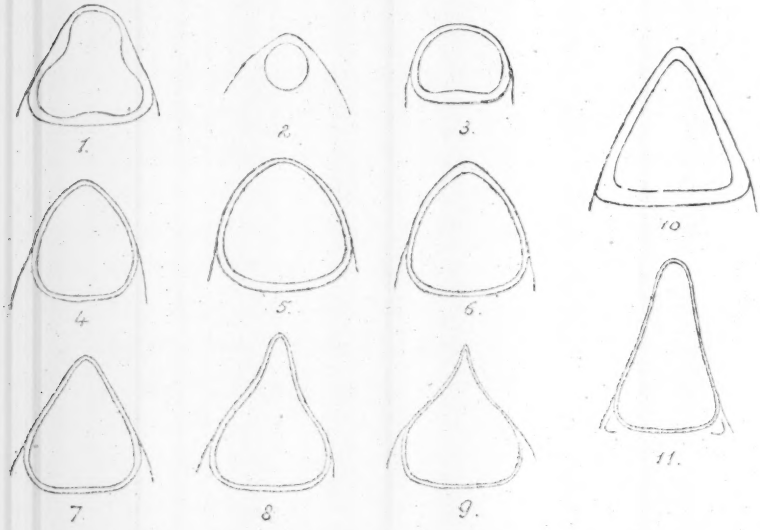
In some species the distal end of the zoœcium in the neighbourhood of the aperture is on the general level of the surrounding zoœcia. Such zoœcia are described as *immersed*. When the distal parts of the zoœcium rise above the general level of the surrounding zoœcia the zoœcium is said to be *emergent*.

The apertures in the various species differ in their actual size, the relation of their diameter to that of the zoœcia, their shape, and the nature of their border. In any given zoarium the shape of the apertures will vary considerably; for instance, from triangular with rounded angles to circular. Therefore, in determining a species, the shape of the majority of apertures must be taken, and if this is done the use of the table below should not prove difficult.

A triangular shape of aperture may be taken as morphologically typical of the family. This triangle may be equilateral; or isosceles with a small distal angle (Fig. 11); or the equilateral triangle may

[1] W. D. Lang: "Jurassic Forms of the 'genera' *Stomatopora* and *Proboscina*," Geol. Mag., 1904, p. 318; and "*Stomatopora antiqua*, Haime, and its related Liassic Forms," Geol. Mag., 1905, p. 258.

be modified and the distal angle be replaced by a sharp point (Fig. 9); again, the distal angle or the two proximal angles, or all three angles, may be rounded off (Fig. 10); and when this is extreme the aperture becomes subtriangular (Figs. 4, 5, and 6) and finally circular (Fig. 2). The extreme rounding of the distal angle only gives a semicircular aperture (Fig. 3). Finally, by the bulging inwards of the sides a triangular aperture becomes trifoliate (Fig. 1).



FIGS. 1–11.—Diagrammatic representations of the apertures of Eleids. (See explanation of figures at the end of the text, p. 68.)

The following table determines the species of the reptant Eleids regardless of zoarial characters. Species marked F occur abroad, those marked B in Britain. Of those marked M the British Museum has examples.

The two species placed in brackets are repetitions, put where they are in case variations in the shape of the aperture have caused specimens of these species to be misplaced in the first instance, when identified according to the table.

The character of the presence or absence of closed zoœcia is put in the table, although its value as a specific index is considered doubtful.

A. Apertures trifoliate. No closed zoœcia ... ... { *Reptelea ligeriensis* (d'Orbigny). F.

B. Apertures circular.

{ *a.* Apertures about $\frac{1}{3}$ the diameter of the zoœcia. No closed zoœcia ... ... } *Reptelea pyriformis* (Michelin). F.

{ *b.* Apertures about $\frac{2}{3}$ the diameter of the zoœcia. No closed zoœcia ... ... } (*Reptoceritites Rowei*, Gregory. B, M.)

C. Apertures semicircular. No closed zoœcia ... ... { *Reptelea actæon* (d'Orbigny). F.

D. Apertures subtriangular to nearly circular.

- *a.* Apertures large (about ·33 mm. diameter).
  - α. Zoœcia immersed. Closed zoœcia numerous — *Semimultelea Dixoni*, n.sp. B, M.
  - β. Zoœcia emergent. No closed zoœcia ... — *Reptoceritites Rowei*, Gregory. B, M.
- *b.* Apertures small (about ·16–·25 mm. diameter).
  - α. Some apertures drawn out distally to a point; rim of apert. low, hardly thickened distally. Closed zoœcia numerous ... — (*Semimultelea acupunctata* (Novak). F, M.)
  - β. All apertures blunt distally, surrounded by a fairly high rim which is generally thickened distally. Closed zoœcia numerous ... ... — *Semimultelea irregularis*, d'Orbigny. B, F, M. *Reptelea pulchella*, d'Orbigny. F, M.

E. Apertures triangular.

- *a.* Apertures equilateral triangles, with the distal angle produced to a point. Closed zoœcia numerous ... ... — *Reptomultelea sarissata*, Gregory. B, M.
- *b.* Apertures isosceles triangles, with small distal angle. Closed zoœcia numerous ... ... — *Reptomultelea tuberosa*, d'Orbigny. B, F, M.
- *c.* Apertures equilateral triangles, with the angles, especially the distal angle rounded. Rim thick and of equal thickness throughout. No closed zoœcia ... ... — *Reptomultelea Reussi* (Pergens). F.
- *d.* Apertures equilateral triangles, with the angles rounded, the proximal angles more than the distal. Rim thick and of equal thickness throughout. No closed zoœcia ... ... — *Reptelea oceani* (d'Orbigny). F, M.
- *e.* Apertures equilateral triangles, with the angles rounded, but some are drawn out distally. Closed zoœcia numerous ... ... — *Semimultelea acupunctata* (Novak). F, M.

In the above table the following species mentioned in the British Museum Catalogue have been omitted:—

1. *Reptelea* (?) *parasitica* (von Hagenow). The specimens referred by Gregory to this species are indeterminable worn fragments. Von Hagenow's[1] and d'Orbigny's[2] figures are also of specimens too worn for reference to any species.

2. *Semimultelea cupula*, d'Orbigny. This, if an Eleid, is not a reptant form.

3. *Semimultelea cenomana* (d'Orbigny). Judging from d'Orbigny's figure,[3] this is a Cheilostome.

The synonymy of the group is given in full in the British Museum Catalogue.

II. British Specimens of the 'genus' *Semimultelea*.

Semimultelea irregularis, d'Orbigny.

A specimen (D 7274) in the British Museum collection, with no information attached, exhibits the zoœcial characters of *Semimultelea irregularis*, d'Orbigny. The zoarium is a multilamellar incrustation whose upper surface is locally raised into knobs. These suggest

[1] Von Hagenow, 1846: Geinitz, "Grundriss der Versteinerungs kunde," pl. xxiii *b*, fig. 7.

[2] D'Orbigny, 1853–1854: Paléontologie Française, Terrains Crétacés, vol. v, pl. 787, figs. 17–20.

[3] D'Orbigny: loc. cit., pl. 788, fig. 3.

the beginnings of cylindrical branches which, if present, would link this form with the 'genus' *Nodelea*.

The pieces of matrix adhering to the fossil are a greensand resembling that of Warminster, and the state of preservation of the fossil resembles that of specimens of polyzoa from that place. The probability, then, of the specimen being of Cenomanian age from the Upper Greensand of Warminster is sufficient to warrant the record of its occurrence.

Semimultelea Dixoni,[1] sp. nov. (Figs. 4, 12.)

A specimen of an Eleid (B.M. D 7845), found by Messrs. C. P. Chatwin and T. H. Withers, and presented by them to the British Museum in October, 1905, exhibits the zoarial characters of the 'genus' *Semimultelea*. It is an incrustation of two or three superimposed laminæ; there are no avicularia. It differs from all the

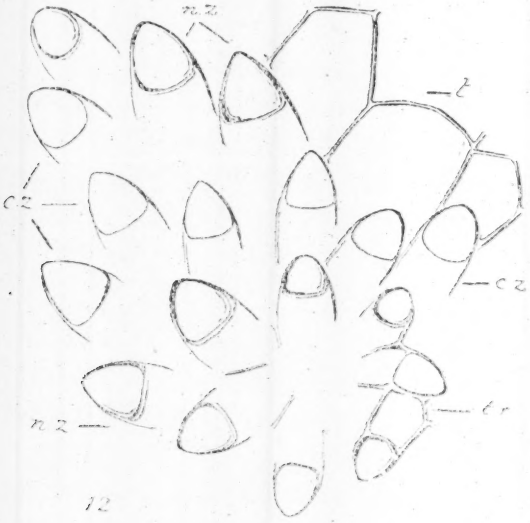


FIG. 12.—Part of the zoarium of the type-specimen of *Semimultelea Dixoni*, sp. nov. (See explanation of figure at the end of the text, p. 68.)

other species of *Semimultelea* in the great size of its apertures, which are about ·33 mm. in diameter. The apertures are subtriangular to nearly circular, resembling in this respect those of *S. irregularis*, d'Orbigny. The aperture is surrounded by a low, rather thin rim, which is not (as in the species just mentioned) thickened distally. Numerous closed zoœcia occur. The apertures are very irregularly distributed, being generally frequent, but rarer in some places. In some parts of the zoarium the zoœcia are

[1] After Frederic Dixon, author of "The Geology of Sussex." Dixon's collection, acquired by the British Museum in 1850, contains many type-specimens of Chalk Polyzoa.

separated by thin, low ridges. They are immersed in the zoarium. Occasionally parts of the zoarium occur, free from apertures, but divided into irregular polygonal areas by thin, low ridges (see Fig. 12).

That species of reptant Eleid which this form most resembles is *Reptoceritites Rowei*, Gregory, from the Lower Senonian of Chatham. The three obvious points of difference are: (1) *R. Rowei* has an unilaminar zoarium; (2) it has avicularia; (3) it has no closed zoœcia. The systematic value of these points will be discussed later. On the strength of the first two it is placed in the genus *Reptoceritites*. The chief zoœcial difference between the two species lies in the fact that the zoœcia of *Semimultelea Dixoni* are immersed, while those of *Reptoceritites Rowei* are very emergent. The specimen was obtained from the Lower Senonian, zone of *Micraster cor-testudinarium*, from the chalk-pit opposite the Rose and Crown Inn, Kenley, south of Croydon, Surrey. The pit is No. 32 of Dibley [1] and No. 113 of Young.[2]

III. The Validity of the 'Genera.'

The table given on pp. 62–3 shows the principles on which the Eleid genera are at present based. Nor are those principles confined to the Eleidæ; they are fundamental in all the families of Cyclostomata. If the systematic arrangement of forms is to be finally established on an evolutionary basis, and the term 'genus' to be used to include those species whose nearest common ancestor differed from that of another group of species, the 'genera' as at present established in the Cyclostomes and Eleids are obviously artificial, for they represent groups of species of various genera in the same stage of phylogeny, and are such as would be the case if, for instance, a given genus of Ammonites included all forms with a keel. Gregory [3] has realised how artificial are the 'genera' in the Cyclostomes, but advocates their retention on the plea that they are "convenient" though "artificial groups of species." But he evidently did not allow that the phylogeny of the group could be found in the astogeny [4] of the colony, for he claims that the Bradford Clay Bereniceas were the direct descendants of the Great Oolite Diastoporas. If once the astogenetic principle is granted the task of establishing new genera, though one requiring much material collected rigidly according to exact horizon, is not as hopeless as he describes; still less in the Eleids where more zoœcial characters are available than in the Cyclostomes.

On reference to the table on pp. 62–3, which gives the specific distinctions in this family, it will be noticed that in regard to

[1] G. E. Dibley, "Zonal Features of the Chalk Pits": Geol. Assoc. Proc., vol. xvi, pt. 9 (1900), pp. 490–491.

[2] G. W. Young, "The Chalk Area of North-East Surrey": Geol. Assoc. Proc. (1905), p. 206.

[3] J. W. Gregory: British Museum Catalogue of Jurassic Polyzoa, 1896, pp. 14–22.

[4] Cumings' term for the ontogeny of a colony. See E. R. Cumings, "Development of *Fenestella*": Amer. Journ. Sci., vol. xx (1905), footnote to p. 169. In a colonial organism like a Polyzoan, three developments have to be considered: (1) ontogeny, the development of the individual; (2) astogeny, the development of the colony; (3) phylogeny, the development of the race.

zoœcial characters the two species *Semimultelea irregularis*, d'Orbigny, and *Reptelea pulchella*, d'Orbigny, appear inseparable. This conclusion has been reached after the examination of specimens in the British Museum collection referred by Gregory to these two species. Nor can they be distinguished zoœcially by the diagnoses given in the British Museum Catalogue. It seems, therefore, that here are two species of one genus—the more primitive possessing a zoarium which, when adult, consists of an encrusting unilaminar sheet of zoœcia; the other, whose adult zoarium is in a more advanced stage, namely, bi- or paucilaminar, passing through an immature unilaminar stage corresponding with that of the adult of the more primitive species.

Reptomultelea Rowei, Gregory, and *Semimultelea Dixoni*, Lang, are another pair of species approximating in zoœcial characters, and differing chiefly from the two preceding species in the size of the apertures. These four species appear to be more nearly related to each other than to any other reptant forms, and possibly form a single genus. Similarly, the species or groups of species marked A, B, C, and E possibly indicate so many different genera. But before more certain conclusions can be formed the erect forms will have to be considered, more specimens must be forthcoming, and especially must the various stages in the life-history of the zoaria of different species be examined. As the facts stand it seems probable that zoœcial characters rather bear generic and zoarial specific significance. Such a general law, however, must not be applied blindly, but always with regard to its bearing upon evolutionary series; and the test for a common genus among several species exhibiting similar zoœcial characters must be the identity of developmental stages in zoarial growth.

IV. Topomorphs.[1]

In the discussion above on generic and specific determination, two characters have been disregarded — the presence or absence of avicularia and of closed zoœcia.

Scattered irregularly among the normal zoœcia of the reptant 'genera' *Reptoceritites* and *Reptomultelea* are individuals of extraordinary shape, generally having the distal portions of the aperture drawn out to form a long tongue. Such individuals have been considered the homologues of avicularia in Cheilostomes, whose function is regarded as protective. The nature of the Eleid avicularia is fully discussed in the British Museum Catalogue.[2] Whatever their physiological significance, the morphological fact remains that their distribution is irregular. Never very frequent, they are often so rare that large portions of the zoarium are free from them. For instance, from the large zoarium of the figured specimen of

[1] ὁ τόπος, 'the place,' and ἡ μορφή, 'the form.'

[2] J. W. Gregory: British Museum Catalogue of Cretaceous Bryozoa, vol. i (1896), pp. 287–288, where references to other writings are given, of which that by A. W. Waters, "Chilostomatous Characters in Melicertitidæ" (Ann. Mag. Nat. Hist., ser. vi, vol. viii, 1891, pp. 48–53), should be read in this connection.

Reptomultelea tuberosa, d'Orbigny (B.M. 36,746), pieces of some size containing no avicularia might be broken, which, if found in the first instance, would have been placed in the 'genus' *Semimultelea*. Unless, therefore, a given zoarium is known to be complete, which is not often the case, there is no means of knowing whether, although no avicularia are seen, they did not occur in the lost portions, because their distribution is rare and irregular, and their presence or absence has not been discovered to be correlated with any other structure.

The distribution of closed zoœcia is not generally sporadic like that of avicularia, but when one occurs others are associated with it, often in the same numbers as the normal zoœcia, generally more frequently, and often forming an area composed of closed zoœcia only. Like the avicularia their physiological significance is a matter of conjecture,[1] nor does the study of the rest of the zoœcia interpret their apparently irregular distribution.

In his diagnosis of *Semimultelea irregularis*, d'Orbigny, Gregory remarks that the zoœcia are "separated by ridges." This is very clearly shown in most of the zoarium of the specimen B.M. D 4867, but not so clearly, if at all, in other parts, and not at all in specimens B.M. D 4818 and D 4843. Again, Gregory cites this character as sometimes occurring in *Reptelea pulchella*, d'Orbigny. Forms possessing it he calls var. *plana*. The character again occurs in parts of the zoarium of the type-specimen of *Semimultelea Dixoni*, Lang (B.M. D 7845). It may be said, therefore, that ridges between the zoœcia occur as a character in various forms of reptant Eleids, in scattered parts of the zoarium; and that the distribution of these areas is determined by unknown conditions.

Parts of the zoarium containing abnormal zoœcia may be found outside the Eleids. The linear arrangement of apertures is specifically distinctive of *Proboscina radiolitorum* (d'Orbigny). But parts of the zoarium are liable to occur in which the arrangement of apertures is irregular. A case of this (specimen D 975) is figured in the British Museum Catalogue.[2]

In the Cretaceous forms of the genus *Membranipora*, a Cheilostome, the shape of the aperture is seen to vary in the same species. In some instances this variation is clearly connected with Astogeny; the different shapes are growth stages. For example, a very general sequence is as follows:—The first formed zoœcia have circular apertures, and approaching the distal parts of the zoarium the shape of the aperture changes to oval, to ovate to very long oval, nearly elliptical[3]; and katagenetic stages are shown. But besides this zoœcia are often found whose apertures are of a shape differing from those in their immediate neighbourhood.

Instances might be multiplied, but enough have been cited to

[1] J. W. Gregory: British Museum Catalogue of Cretaceous Bryozoa, vol. i (1899), p. 250.

[2] British Museum Catalogue of Cretaceous Polyzoa, vol. i (1899), p. 50, text-fig. 1.

[3] These terms are used with their botanical significance, as defined, for instance, by Asa Gray, "Structural Botany," 1879, p. 95.

show that this phenomenon of isolated patches of abnormal zoœcia occurs commonly among Polyzoa. And for these local forms I propose the name *Topomorph*, a purely morphological term, describing any part of the zoarium in which the zoœcia differ from those of the rest of the zoarium. Thus it includes, for instance, growth stages, "localised stages,"[1] peculiar forms due to external conditions such as overcrowding or a different food supply, to possible intermittent or seasonal causes such as reproductive activity. The characteristic of the term is its freedom from physiological implication, and herein lies its value, for it can be used in morphological descriptions before the origin or use of the described parts is known. Whereas the terms variety (as in the case of var. *plana* above), stage, etc., imply systematic or developmental relations which on further investigation may or may not be found to hold; and the term 'form' (as, for instance, *Sparsicavea carantina*, d'Orbigny, form *franquana*) is far too useful and too widely used as a general term applicable to zoœcium, zoarium, or parts of a zoarium, and to members of other groups of organisms, to be limited by a technical and special significance. To describe a part of a zoarium of a species of *Membranipora* in which the apertures were ovate as a topomorph of species *x*, and to describe it again as a growth stage of the species, because it has been discovered that a stage with circular apertures always precedes and one with elliptical apertures always succeeds it, implies no incongruity nor contradiction, because the first is a morphological term describing structure, and the second a physiological term describing the behaviour of the species.

It is hoped that this paper, though adding little to what is already known about the Eleids, may be of some use to the collector in helping him determine the species by presenting them in a tabular arrangement, that the occurrence of forms new to England may stimulate further collecting, and that the suggestions concerning generic distinctions may place in a more hopeful light the ultimate discovery of the evolution within the group and of the true relations of its members among themselves.

EXPLANATION OF FIGURES IN TEXT.

FIGS. 1–11.—Diagrammatic representations of apertures of Eleids.
All the figures are very much enlarged, but their sizes are not comparative.

FIG. 1. Aperture of *Reptelea ligeriensis* (d'Orbigny). After d'Orbigny.
,, 2. Aperture of *Reptelea pyriformis* (Michelin). After Michelin.
,, 3. Aperture of *Reptelea actæon* (d'Orbigny). After d'Orbigny.
,, 4. Aperture of *Semimultelea Dixoni*, n.sp. From the type-specimen (B.M. D 7845).
,, 5. Aperture of *Reptoceritites Rowei*, Gregory. From the type-specimen (B.M. D 4244).
,, 6. Aperture of *Semimultelea irregularis*, d'Orbigny. From the specimen B.M. D 4867.

[1] I.c. local recapitulations. See R. T. Jackson, "Localised Stages in Development": Mem. Boston Soc. Nat. Hist., vol. v, No. 4 (1899), pp. 92, 139, 141. See also W. D. Lang, "*Stomatopora antiqua*, Haime": GEOL. MAG., 1905, pp. 259, 260.

Fig. 7. Aperture of *Semimultelea acupunctata* (Novak). After Novak.
" 8. Ditto.
" 9. Aperture of *Reptomultelea sarissata*, Gregory. From the type-specimen (B.M. D 7106).
" 10. Aperture of *Reptomultelea Reussi* (Pergens). After Pergens. Other zoœcia in Pergens' figure have a much more rounded distal angle.
" 11. Aperture of *Reptomultelea tuberosa*, d'Orbigny. From the specimen B.M. 36,746.
" 12. Part of the zoarium of the type-specimen of *Semimultelea Dixoni*, n.sp. (B.M. D 7845), showing normal zoœcia (*n.z.*); closed zoœcia (*c.z.*); a topomorph with ridges between the zoœcia (*t.r.*); and a topomorph composed of areas marked out on the zoarium by raised ridges, but with no closed or open apertures (*t.*). × about 24. Somewhat diagrammatic.

V.—Machine-made Implements.

By F. J. Bennett, F.G.S.

ATTENTION has lately been called by M. Marcellin Boule to the production in cement-mills in the Commune of Guerville, near Mantes, of all the more characteristic forms of Eoliths, and of these he has given photographic reproductions. The evidence for the necessarily artificial shaping of Eoliths had for many years been questioned by him, because he had found chipped flints of this character in the midst of Oligocene or Miocene beds in Auvergne and in the Velay; and it seemed imprudent to infer the existence of man in those early stages of the Tertiary period in the absence of osteological evidence.

In speaking here of machine-made implements I do so advisedly, because all stone implements were once referred to natural or supernatural causes; the obvious arrow-head, for instance, being termed an 'elf-bolt.'

M. Boule, however, seeks only to show that stones shaped like Eoliths may be produced by Nature, because he finds that they are produced by certain pseudo-natural, machine-made torrents, and so considers that Eoliths are due to such torrential action. Yet the Eolithic deposits known to the writer do not seem to indicate torrential action.

The first objection is that M. Boule compares known and unnatural agencies with natural ones, and the analogue of his machine-made torrent would be hard to find in Nature and would be most exceptional there, and yet to this he would refer all Eoliths.[1] The Mantes wash-mill apparently deals only with flints fresh from the chalk, while the flints from which the Kent plateau Eoliths were made were mostly tough and much weathered, and not as a rule such flints from which good chipping can be obtained; and that may account a good deal for their rough execution, and for their non-acceptance by some observers.

Anyone who is a flint-knapper knows that the results obtained from the one kind of flint are very different from those obtained from the other, that the fracture varies with the flint, and that in

[1] *Nature*, Aug. 31, 1905, p. 438; Sept. 28, p. 538; and Oct. 26, p. 635; see also *L'Anthropologie*, vol. xvi, p. 257, in which the detailed observations of M. Boule are published.

some flints the human fracture is not distinguishable from the natural fracture.

The mill also rotates at a definite speed for a definite time, and so cannot compare with Nature. In order to get any results of value, the flints should be examined first, and samples taken out from time to time and compared, and yet the flints in question are only taken out after about 29 hours' interval.

There is another complication, which also seems to introduce a human element, if we may say so, in the case of the harrows with chain attachments, and these harrows in one of the mills visited by the writer were also weighted with old gear wheels, etc. So that, added to the impact of flint against flint, there is also a possible knapping action due to the teeth of the harrows and to the links of the chains, and these, in shape and possibly in effect, would compare with the pebbles used in knapping; the teeth, too, of the old gear wheels may also be chipping agents. Hence it becomes more difficult to say by which of these agencies, or by their combination, the fractures are produced. Thus any quasi-human results may be due to these quasi-human agencies introduced.

It is also possible, if the area contains worked flints, that these may be introduced. And in the cases we have investigated such flints do occur in the area. The analogy also with Nature would be closer if the harrows, etc., could be removed and the flints subjected only to the torrential action of the water.

So much for some of the objections. I will now give some account of the observations I have just made at certain wash-mills in Kent. These mills are confined to brickyards. The results are found to vary with the kind of flint, with that of the matrix, and with the proportion of this to the flints and to their size. I will take the mills as I observed them, but the washing process was not then in operation in any one of them.

The first was that at Pascall's Kiln, at Platt, near Wrotham, Kent. There, resting irregularly on the Gault, is an angular white flint gravel much weathered, together with some much worn flints. At another part of the brickyard is a sandy loam with some blocks of sandstone and a few small scattered flints, and this seemed to be washed together with the Gault, as the wash-heap also contained sand and rounded lumps of sandstone.

The small angular flints were not affected at all by the milling action, and the other flints only slightly so. Samples of all those that were at all like implements were taken, and most of those were Eolithic in form merely, and photographs of these would pass as good Eoliths, but some of rude palæolithic form were also found. The flint being of a coarse and cherty nature, the 'work' was rough in accordance with this material.

On two of the specimens the writer, who can knap so that he can deceive an expert, and can treat the chipped flint so as to remove the new look, tried his hand, and chipped and bruised and 'treated' (the work of a few minutes only) one side of each specimen, so successfully that there was no real difference between his side and

the milled side. So that one side was possibly mill-made and the other certainly hand-made. This would seem to leave the case of the mill, in this instance, as non-proven, or rather in favour of man.

The other place visited was Temple Farm Brickyard, near Strood, Rochester. Here there are two wash-mills, a lower and an upper one, each with its refuse heap. Here the conditions in the one differed from those in the other, and so did the 'work' on the flints. At the lower brickyard is a long extended section of brickearth across the wide trumpet-mouthed opening of the valley. This shows 20 feet of clean sandy loam, laminated in places, and with occasional small seams of pellety chalk and very small angular flints and small pebbles. This loam is thinly capped by stony loam with some scattered flints, some angular and others more or less worn. The lower refuse heap was composed mostly of a mixture of fine flinty gravel with many small pebbles, and much pellety chalk and many lumps of 'ginger,' and very few large flints. Some of these, which were like those fresh from the chalk, were very little rolled or chipped, and the reason was plain, as they were contained in a matrix that kept them from contact with each other, and so their original condition was little affected.

The upper mill is higher up the valley; there the brickearth was dug in two places, one in a terrace on the valley side and the other in the bottom of the valley. That in the terrace showed six feet of stony loam resting on a marly, pellety chalk, with many large and mostly angular flints, little worn and like those fresh from the chalk; the other flints were much worn and weathered, with a few pebbles. The second section had fewer flints and was mostly in the pellety chalk. Thus this brickearth seems due to the decalcification of the chalky waste formed during the denudation of the stiffer and more stony loam in the upper, and the finer washed loam in the lower part of that valley. One great refuse heap at the upper mill was mostly composed of large flints, some of Eolithic form, but evidently shaped, as the old patina showed, before they entered the mill, while one or two were of palæolithic form and one neolithic. Here the chipping, rolling, and bruising due to the mill apparently, though slight, was much more noticeable than at the lower mill, as here there were so many more and larger flints to act on each other and to be acted on by the harrows, etc. A very good imitation of beach action was seen in the many rounded lumps of chalk, etc., from the loam in the large refuse heap.

All that the mill then seemed to have done was to round and bruise and re-chip in an irregular manner the sharper original edges, as offering the least resistance. Where old indentations occurred, it would seem that the teeth of the harrows had found these out, as they were re-touched in some cases and the old patina removed in places. Thus it would appear that the mill, like the sea, in the writer's opinion, rounds rather than shapes, and so deforms any flints that had been previously chipped into a definite shape.

Though he has not visited any chalk wash-mills, the writer has seen some flints from one near Sevenoaks, and these were thin

pieces of flint irregularly chipped at the edges, but not apparently 'formed' in any definite way.

In chalk wash-mills, as in the examples mentioned, much must depend on the proportion of the flints to the mass of the chalk and on their size, as the more numerous and the larger the flints, the more will they be affected, and *vice versâ*. Thus the power of the mill, as able to shape Eolithic flints, must, in the cases observed by me, be considered as non-proven.

The difficulty of the whole question consists in this, that we are trying to decide where no final decision seems possible. For those who hold that certain flints are due to natural causes have never seen, or can see, Nature doing what they would refer to Nature, and those who uphold the human origin of the flints could never, of course, have seen them actually made by man. But we have actual proof that man has and does fashion certain stone tools, and therefore have good reason for asserting that man did make some of these early tools, and we also know that man improves on his early work, so that the best forms of these cannot be man's earliest efforts. The difficulty always will lie in fixing the starting-point of his 'prentice hand.

The stages in the progression from the ruder to the more perfect forms were probably these. As soon as man found that some adjunct to the hand was needed in his conflict with Nature and the beasts, sticks, bones, shells, and stones were used. Of these, only stones, for the most part, have remained.

The stones, in the first instance, would be those best adapted to his needs, and were so selected. Next it might occur to him that he might imitate those *natural* forms: hence the difficulty to distinguish between the apparently natural forms and the possible artificial ones, both having only one sharp or sharpened edge. Then he would gradually learn so to adjust the angle of incidence as to extend the chipping all over the flint, and at last to select the kind of flint that gave the best results. The process must have been a gradual one, with intermediate stages, with reversions perhaps to older and ruder forms, and the difficulty will always lie in fixing the starting-point of the undoubted artificial stage, and I do not think that the wash-mill evidence will help to do this. But it may cause those who have been too ready to accept worked flints to be more careful in the future.

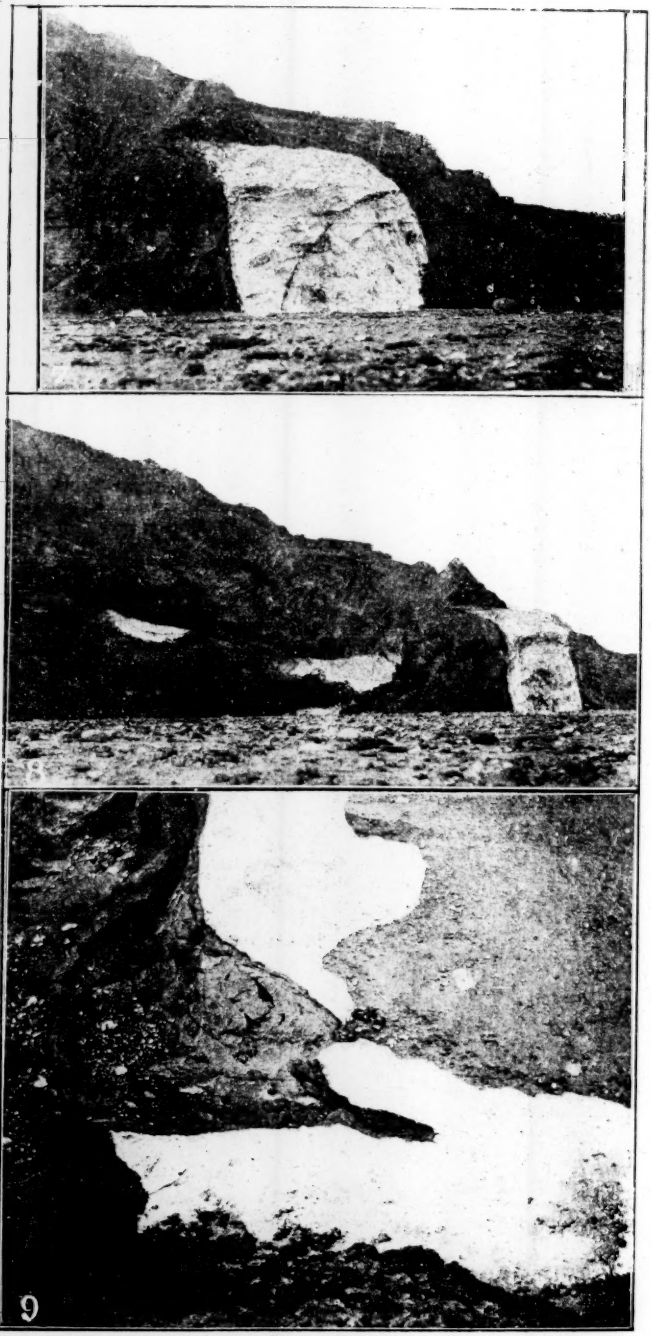
VI.—Further Notes on the Stratigraphy and Fauna of the Trimmingham Chalk.

By R. M. Brydone, F.G.S.

(PLATES IV AND V.)

(*Continued from the January Number, p.* 22.)

DOWNWASHED sand and mud much obscured the section, but the clay appeared to be definitely continuous, while the chalk might be continuous under the mask of mud, but did not seem likely to be so. The section suggested very strongly a flat sheet of clay



Views of the Trimmingham Chalk Bluffs, Norfolk Coast.

(To illustrate Mr. R. M. Brydone's paper.)

pushed at a level some way below the beach against a backward sloping and then overarching surface (e.g. the side of a cave), which it had followed until doubled back upon itself.

The masses of chalk in the bay, where accessible, all showed *Ostrea lunata* chalk, except the stringer from the bluff. This was accessible from above, and was then composed solely of the grey chalk.

It was quite clear that the landward face of the bluff was not parallel to the coastline, but ran about east and west, the bluff being therefore a rude triangle with its apex towards the north. The landward face was covered by what appeared to be crushed blisters of finely laminated clay apparently formed round projections in the surface of the chalk.

In the Autumn of 1904 I got desperate at my inability to satisfactorily sketch the constant changes which were taking place, and borrowed a camera, and since that time I have a fairly continuous series of photographs, some of which are reproduced as Figs. 6 to 18 in the plates illustrating this article. Unfortunately I had had no previous experience of photography, and I have always chanced upon dull and cloudy weather, so that I may be forgiven for the imperfection of the photographs. As it is, they show far more than I ever dared to hope for. They are all, I think, self-explanatory except Fig. 9, which was taken from the summit of the bluff, and in which the boundaries between the grey chalk above and below and the *O. lunata* chalk between is traceable in the 'slope' (the nearer piece of chalk) by a slight variation in shade.

During the period covered by these photographs erosion has been very rapid at this point (the clay seen on the left hand of the bluff in Fig. 13 was faced with chalk of fair thickness six months previously) (Fig. 8), and several further points of interest have been disclosed. The most important is perhaps that shown in Figs. 10, 11, and 15. The cutting back of the main cliff has provided a section across what appears to be an erratic mass of rudely stratified flint shingle, varying from very coarse to fairly fine, with a bed of sand in the middle and a long thin slice of chalk at its left hand, the stratification being vertical. The slice of chalk, though nowhere more than two feet thick, contains both *O. lunata* chalk and grey chalk with an occasional grit seam at the base throughout the whole length I have been able to examine, the *O. lunata* chalk being next the clay which forms as it were the backing of the mass. The lower end of the chalk slice was recently exposed, and the clay was seen to run down beside it and then turn at right angles in under it (Fig. 15), with the banding parallel to the surface of the chalk, which seems inseparable from the junction of clay and chalk here. The whole thing very strongly suggests a piece of shingly beach set on end, the chalk representing the basement bed on which the shingle was heaped up. The rude stratification of the shingle is what might be expected from the sifting together of the pebbles of similar size which takes place in every beach, the coarsest part being that next the chalk. This huge mass of shingle, which can hardly

have been transported from any distance, as it would not have held together, forms an interesting parallel to the masses of coarse shingle which lie on the top of the northern part of the south bluff as recorded in my previous pamphlet (see also Fig. 1 hereto).

Another point of interest is the behaviour of the grey bed in the seaward face of the bluff. As this was cut back the grey bed developed a deep pocket, shown just beginning in Fig. 7 and complete in Figs. 13 and 17, at the bottom of which the gritty basal seam thickened considerably and became exceptionally coarse. (It will be noticed in these figures that the two upper flint beds shown in fig. 1 of my previous pamphlet have become comparatively indistinct, while the third has become very marked. At the moment of writing the second is regaining its importance.) On the left-hand side of this pocket the base of the grey chalk rises very sharply, so that the chalk which strings out into the clay, thin as it is, becomes, as on the other side of the bluff, composed of a layer of *O. lunata* chalk below and a layer of grey chalk above. There is clearly at this point a very strongly marked unconformity between the two beds of chalk.

Another point is that *O. lunata* chalk has come in between the grey chalk and the clay in the cross section at the end of the north side of the grey chalk bay and at several other points in this mass where the grey chalk and clay were previously in contact, so that it seems fair to assume that the distance by which the grey chalk overlaps the *O. lunata* chalk is slight everywhere. Whenever the grey chalk has been removed from off the *O. lunata* chalk beneath it the latter has always presented a decidedly wave-worn and smoothed appearance.

This grey chalk, as before stated, presents some remarkable peculiarities besides its basement bed of grit with flint and chalk pebbles. It is very soft, but contains a great abundance of hardish lumps of varying shades of grey which are not clearly rolled, but have very smooth and suspicious outlines. These lumps are very similar in texture, and, so far as I know, identical in fossil contents with their grey matrix. The flints present two facies. One, which is generally small, is dark grey throughout and very soft, being often little more than a central mass of spongy texture, but no definite shape, surrounded by a very thin skin, very imperfectly silicified and easily cut with a knife on slight pressure. The other type appears to be confined to the base of this chalk, and includes nearly all the large flints. It is very thoroughly silicified and black inside with little or no cortex, and light bluish grey outside. These, like the included lumps, suggest gentle rolling, but contain only the same fossils as those of the grey matrix, including the peculiarly characteristic ones, and certainly no specimen of *O. lunata*, which occurs in profusion in the flints of its own horizons. The bed as a whole is certainly not reconstructed, for the grey matrix abounds in fragile fossils in absolute perfection, the most striking being *Ostrea inæquicostata*, bivalved *Ostrea ungulata*, and numerous branches of *Vincularia* and other Polyzoa. The fossils show the

unconformity between the grey chalk and *O. lunata* chalk as clearly as the stratigraphy. *Ostrea lunata* and the bun-shaped *Echinoconus* are unknown in the grey chalk, which is full of *Ostrea inaquicostata*, *O. canaliculata*, and *Terebratula obesa*, none of which have ever yet been found in the *O. lunata* chalk. There are very similar grey beds on the foreshore underlying white chalk without *O. lunata*, which passes up into *O. lunata* chalk, but below they are cut off by a fault, and until we know either what overlies the grey chalk of the bluff or underlies the grey chalk of the foreshore it is not safe to identify the two sets of grey beds, though it is very tempting, the similarity being very striking, especially in the fossils.

At the beginning of October, 1905, the clay behind the bluff was broken through by the waves, and by the middle of the month the bluff had been completely isolated and a secondary bluff formed behind it out of the seaward face of the *O. lunata* chalk underlying the 'slope' of grey chalk, which had by this time become mainly a slope of *O. lunata* chalk showing several lines of flint dipping gently seaward. The cross section of this secondary bluff showed gently arched lines of flint, from which it was clear that this secondary bluff was the top of a gentle anticlinal fold rising towards the land, exactly like the ridge forming the southern part of the south bluff. It was, however, underlain where its base was clear of sand by clay visibly continuous in the south bay with the clay underlying the chalk masses. The same waves that had breached the clay pinnacle had also cleaned the section in the south bay, which is recorded by Fig. 17. The clay appeared to have pressed upwards from under the mass of chalk nearer the bluff and carried up with it on its surface the mass high up in the cliff, for the two were connected by a very thin but unbroken line of chalk which kept the clay above the masses of chalk from quite touching the clay which emerged from beneath them. A similar but more partial appearance was presented in the north bay by the clay which emerged from under the 'slope' and passed up into the cliff, only to arch over and, as before stated, pass down beside and in under the erratic slice of chalk. Both the masses in the south bay, i.e. the lateral section of the 'secondary bluff' and the mass seen high up in the cliff, were composed of *O. lunata* chalk with about a foot of grey chalk above separated by the regulation grit seam with pebbles, and above the grey chalk came about six inches of very regularly bedded sharp grey sand with one interlaminated seam of black clay, and above the sand about 2 feet of dark bluish grey clay. Between the two masses of chalk the sand was cut out by the clay above it, but over the masses themselves it was very regular. Above the bluff it passes into a coarse gravel.

The most recent exposures of the north side of the bluff itself appear to show an actual inversion of all the chalk below the thick flint. These flint lines are not clearly marked on this side, but their appearance is quite consistent with and indeed suggestive of their being actually inverted, and the hypothesis that they are actually

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The most recent exposures of the north side of the bluff itself appear to show an actual inversion of all the chalk below the thick flint. These flint lines are not clearly marked on this side, but their appearance is quite consistent with and indeed suggestive of their being actually inverted, and the hypothesis that they are actually

inverted is made very probable by the fact that the seams of *O. lunata* up to and including that immediately below the thick flint follow the same inverted course, a fact pointed out to me by Mr. Bidder. Now it will be remembered that the *O. lunata* chalk was continuous across the gap, and that the gap was quite recently fairly narrow, and though no bed of flint happened to occur in the arch of *O. lunata* chalk crossing the gap, I am convinced (and Mr. Bidder is equally positive) that the thick flint in the bluff was identical with the flint line at a corresponding height in the 'secondary bluff' (Fig. 14). If we are right, then the thick flint was not involved in the inversion. That being so, we should expect to find filling the gap which would otherwise be left between the thick flint which continues more or less horizontal, and the beds below which break away from it, an area of reconstructed chalk, and this is exactly what does occur there. The sketch below will show what is meant:—

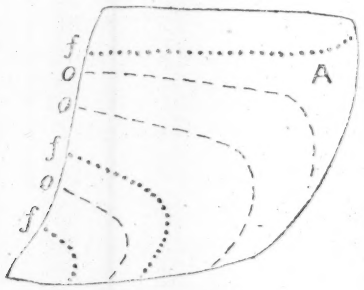


Diagram-sketch of the north-west face of bluff.

f, f, f, flint bands; *o, o, o*, seams of perfect *O. lunata* in section.
A, area composed of chalk crowded with comminuted *O. lunata* and no other fossils.

Now I think we are entitled to assume (until the contrary is shown) that the inversion is a result of the same, or practically the same, force which has so greatly tilted the beds which are not actually involved in the inversion, for both the tilting and the inversion must have been produced before the deposition of the grey chalk on the upturned ends of the tilted strata, since neither the tilting nor the inversion has affected the grey chalk, and that fixes the tilting and the inversion as of late Cretaceous age. Evidently all the beds now appearing in the bluff were tilted together, but by the time the angle had been reached at which the uninverted beds now stand, these beds must have been raised above the plane at which the thrust was operating, and the lower beds, being still in that plane, must have been forced to part company with the uninverted beds, no great matter, as the whole could by that time have only been lightly consolidated, and turn under themselves. This view conforms very well with Lyell's figure of the bluff when it was about twenty times its present length. This figure shows at the north corner a small area of chalk with a steep dip which

flattens out southward to quite a gentle dip over a comparatively very extensive area, showing the steep dip to be very local. Probably we have in the bluff of to-day a remnant of the steeply dipping area only of Lyell's bluff, but whether that is so or not Lyell's figure is a very strong argument against assuming the general prevalence of a steep dip at this point.

The only possible explanation of these local phenomena seems to be one on the lines of the original and ingenious theory of Mr. Clement Reid, varied by postulating the lateral thrust as of Cretaceous age, directed almost due south and very local, and leaving the thrusting agent altogether indefinite. Except at this very point the thrusting force only created a gentle anticline. This anticline of greatly varying sharpness must have been exposed to denudation, which planed off the upper part and more or less flattened the sides, and the surface so formed was then resubmerged and the grey chalk deposited on it to a minimum thickness of three feet. At some date shortly before the formation of the glacial beds, the chalk must have been again raised and exposed to a south-westerly sea, which formed caves in it which were filled by the first inflow of boulder-clay. The bottoms of these caves are probably well below the present beach level, and we only see horizontal sections through the roofs and the upper surface of the infilling clay, which of course then appears to be underlying the thin edge of the broken-through roof by natural deposition. The detached masses of chalk seen in the cliff behind the bluff have clearly been carried up by a mass of clay from below, and represent parts of the roofs of these caves, which were too weak to resist the upward pressure of the clay. Possibly this upward pressure was applied at a much later date than the infilling of the caves, for the thin line of chalk recorded as connecting two masses of chalk is strongly suggestive of chalk, so to speak, rolled out between the upper and lower clay, and this could only take place by a fresh movement of the lower clay after the upper clay had taken up its present position. It is also suggested by the regular blending of the deposits immediately overlying the chalk just at this point that after the first influx of clay had filled up the sea bed to the level of about the top of the chalk there was an interval, during which the above-mentioned regular deposits were formed on the new sea floor so created, before this sea floor was covered by the upper clay, and then broken up by renewed motion in the lower clay.

5. *Other Exposures.*

A new feature of interest is the exposure for a short time of a patch of *O. lunata* chalk, about 30 yards by 12, some 340 yards to the south of the south bluff, i.e. roughly, intermediate between it and the short ridge exposed some years ago at the foot of the cliff under the brickfield (which latter I will call for convenience the brickfield chalk). This new patch of chalk was practically touching the base of a great mass of firm clay which forms at present the first headland to the south of the south bluff, and appeared to pass

under this clay in the cliff and also under clay to the northward, its other boundaries being formed by sand. It appeared to represent the top (or rather a section across the upper part) of a flat ridge running and sinking in the usual direction about 30° south of east. Its southern and eastern ends were capped by a practically continuous sheet of flint, identical in appearance with a sheet of flint which I had previously observed on the foreshore close by coating one side of a ridge of *O. lunata* chalk heading in this very direction. The brickfield chalk recorded in my previous pamphlet I have never seen again, but once or twice in 1900–1904 there just showed through the sand some way further down the beach a narrow ridge of *O. lunata* chalk once visible for as much as 30 yards, and apparently running out to sea in much the usual direction, and in a line with the first recorded brickfield chalk. This ridge has been frequently just visible during 1905, and in October, 1905, it was gradually exposed to a length of over 66 yards. It was nowhere more than 4 feet and rarely more than 2 feet thick, and dipped very steeply to the north. It seemed very remarkable that such a long thin ridge should have been preserved on a foreshore, though there were strong indications that it increased greatly in width at a very short distance deeper down. But a still more remarkable thing was revealed on close examination, i.e. that throughout practically its whole length it was composed of a layer of *O. lunata* below and a layer of grey to white chalk above, separated by a grit bed full of rolled flints and chalk, and agreeing most exactly, except for its greater thickness (maximum at least 6 inches) and the greater size of the flint pebbles, with the grit bed at the base of the grey chalk in the north bluff over a mile away. I have little hesitation in identifying the two grit beds, for though the brickfield chalk above the grit bed was not uniformly grey, it contained many hardened and apparently rolled lumps of chalk. I could not find there any of the characteristic grey chalk fossils, but the total amount of chalk exposed was very small, and the physical identity is very pronounced.

EXPLANATION OF PLATES.

Views of Trimmingham Chalk Bluffs, Norfolk Coast.
Various views of the North Bluff and the exposures in the bays on either side of it.

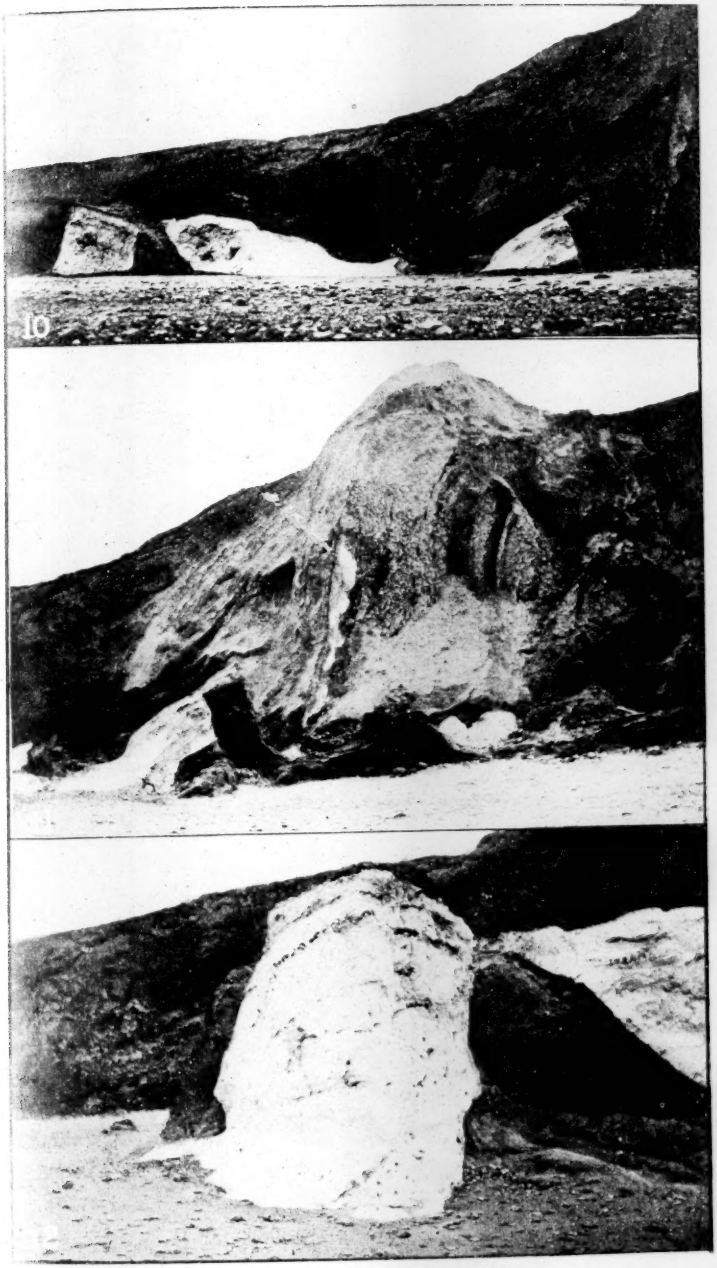
Plate IV.

Fig. 7.—Photograph taken November, 1904.
,, 8.—South bay: November, 1904.
,, 9.—Head of north bay from top of bluff; May, 1905.

Plate V.

Fig. 10.—North bay, showing slab of chalk on end in cliff: April, 1905.
,, 11.—Showing slab of chalk and mass of stratified shingle on end; May, 1905.
,, 12.—North Bluff, seaward aspect; May, 1905.

(To be concluded in our next number.)



Views of the Trimmingham Chalk Bluffs, Norfolk Coast.

(To illustrate Mr. R. M. Brydone's paper.)

VII.—Radium and the Radial Shrinkage of the Earth.

By T. Mellard Reade, F.G.S., F.R.I.B.A., A.M.I.C.E.

IN his Presidential Address to the British Association, South African Meeting, 1905, Professor G. H. Darwin points out that the presence of radio-active materials in small proportion in the sun would serve to explain the present radiation, and "that concentration of matter is not the only source from which the sun may draw its heat." Professor Darwin goes on to explain how this enables us to extend the possibilities of geological time beyond that to which some physicists would limit us.

My object in writing this is to point out that if the sun's heat is kept up by the presence of radio-active materials the same must follow with regard to the earth. The rate of cooling of the earth must consequently be slower in proportion to the quantity of heat generated by the radio-active matter present in its substance.

It further follows from these premises that if the generation of heat by these radio-active matters in the earth equals the dissipation of it at the earth's surface the globe will be kept at the same *average* temperature. If this be the condition of the earth at the present time there can be no radial contraction taking place unless due to some other cause than loss of heat, and the same may be predicated of any previous period.

This is no doubt stating an extreme case, but if, on the other hand, we assume that only a portion of the heat lost by the earth by conduction and radiation is replaced by that generated by radio-active bodies, by so much will the radial shrinkage be reduced and the mountain-making activities on the contraction hypothesis rendered less efficient.

It has been shown by Osmond Fisher and myself that the gradual dissipation of the initial heat of the earth, considered simply as a cooling body, that has taken place in the past is quite insufficient to provide the radial contraction demanded by the contraction hypothesis.[1] If any of this lost heat is renewed this inefficiency is proportionately intensified.

Our ideas of the constitution of matter are undergoing serious changes, and it becomes increasingly important that geologists should keep themselves abreast of the times. The bugbear of a narrow physical limit to geological time being got rid of, we are free to move in our own field of science. The methods of geology have this advantage over those of pure physics, we can more readily appeal to nature for confirmation or disproof.

May I be permitted to point out that while the discovery of radium has shaken the foundations of what may be designated the mathematical theory of the earth, it strongly supports those who like myself have long contended that the forces which create mountain ranges, raise continents, and give external form to the

[1] Fisher: "Physics of the Earth's Crust." Reade: "Origin of Mountain Ranges"; "Evolution of Earth Structure."

earth reside in the earth itself, and that "the earth is not merely an inert mass cooling in space."[1]

Our conception of the geologic potentialities of matter has been marvellously widened by the recent discoveries. How these discoveries may affect our views of the interaction of matters as explaining geological changes remains to be decided when the new methods are established on a firm basis, of which there seems to be an early prospect.

NOTICES OF MEMOIRS, ETC.

Abstracts of Papers read before Section C (Geology), British Association: South Africa, 1905.

I.—On the Marginal Phenomena of Granite Domes. By Professor Grenville A. J. Cole.

IN examining the gneisses of the counties of Donegal and Tyrone, which have been in part regarded as sheared Archæan masses, the author was led to conclude that the main structures are due to igneous flow, and that the most marked gneissic structure occurs where previously foliated sedimentary and igneous material has been incorporated with an invading granite. The patches of foliated gneiss in the granites of Donegal are thus remnants of considerable masses of older rock that have been absorbed; and the phenomenon of banded gneiss arises characteristically as a marginal feature of granite domes. Foliation is found in surrounding masses parallel to that in the granite, and at the same time parallel to the surface of junction, for the simple reason that the granite has picked off, leaf by leaf, the layers of foliated rock against which it rose. The author thus ranges himself with those who ascribe the most profound metamorphism to igneous rather than to dynamic action, and ventures to suggest that similar conclusions may be drawn from the rocks of the Malmesbury series in the west of Cape Colony, where a commingling of rocks appears to have taken place during a period of subterranean flow.

II.—Magmatic Segregation of Sulphide Ores. By Dr. A. P. Coleman.

THE formation of ore bodies by magmatic segregation in eruptive rocks has long been admitted as regards magnetite and titaniferous iron ores, but the formation of sulphide ore bodies in this way has been disputed by many geologists. The pyrrhotite ores of nickel in Norway were first recognised by Professor Vogt as having this origin; and his theory has been applied to the Sudbury nickel ores by various geologists, and opposed by others. The recent complete mapping of the eruptive sheet, with which the Sudbury ore bodies are all connected, proves that they are really

[1] "Evolution of Earth Structure," p. 28.

segregated from the eruptive rock and form an integral part of it, with every gradation between ore and rock. It is believed that gravitation played a large part in the segregation, since the ore bodies are regularly found at the lowest points in the lower edge of the norite-micropegmatite sheet with which they are connected.

III.—On the Geology of South Victoria Land. By H. T. Ferrar, M.A.

I. The knowledge we had of South Victoria Land previous to the departure of the "Discovery" was mainly acquired by the expedition under Sir James Clarke Ross in H.M.S. "Erebus" and H.M.S. "Terror," in the years 1839–1843. His discoveries may be briefly summed up thus:—

(*a*) A great range of mountains, which rise occasionally to heights of 15,000 feet, and extend in a north and south direction for at least 500 miles.

(*b*) The presence of volcanic and plutonic rocks in this area.

(*c*) An open shallow sea south of the Antarctic circle.

(*d*) An active volcano, Mount Erebus, over 12,000 feet high, emitting flame and smoke in great profusion.

(*e*) A wall of ice, the Great Ice Barrier, on an average 150 feet high and about 470 miles long.

In 1899 the "Southern Cross" expedition brought home from Cape Adare specimens of granites, basalts, and quartz slates, but unfortunately the latter proved to be unfossiliferous.

II. This section deals with the *volcanic islands* off the coast, commencing with the Balleny Group, in latitude 66° S., and passes on to the rocks of the mainland in latitude 77° S. The rocks from the islands are chiefly basalts and tuffs, though intrusions of trachyte are fairly common. Edward VII Land and the volcanoes on the mainland are included in this section, as the latter, at any rate, belong to the recent volcanic eruptions of the area. All the volcanoes are undenuded cones, and are usually situated in isolated positions, and contrast strongly in outline with the rugged scenery of the main mountain range.

III. *The Continental Range.* The great range of mountains discovered by Sir James Ross has been proved to be at least 800 miles long, and to have some remarkable features common to the whole length. This great mountain range is divided into smaller ranges, to which distinguishing names have been given; but only one, the Royal Society Range, has been examined in detail by the expedition. The rocks that compose the range are conveniently separated into four distinct groups—namely, gneisses, granites, sandstones, and dolerites. The sandstone, to which I propose to give the name Beacon Sandstone Formation, provides a convenient stratigraphical datum-line, with reference to which the other phenomena may be considered.

(i) *The Gneissic Rocks* occur at sea-level and below a sequence of rocks which is at least 12,000 feet thick, and may be safely regarded

as forming the ancient platform on which the central part of South Victoria Land is built. The foot-hills of the Royal Society Range and the lower portions of the Cathedral Rocks are composed of this class of rock.

(ii) *The Granites* have been encountered at the north end of the Royal Society Range, where they rest upon gneisses, and dykes of granite pierce the gneissic series. At Granite Harbour this type of rock is found as a huge boss, and is probably covered by a sheet of dolerite. Where the Ferrar Glacier forks, a junction of dolerite and granite proves that there are two distinct developments of granite, one older and one younger than a certain sheet of dolerite.

(iii) *The Beacon Sandstone Formation* is met with at a height of 4,000 feet above sea-level, and about 40 miles from the sea. It appears to be nearly 3,000 feet thick, and near the top indeterminable fossil plants were found. The bedding is practically horizontal, and the rock is remarkably uniform in texture. The surface upon which it rests has not yet been discovered.

(iv) *The Dolerite Sheets* produce the plateau features characteristic of that rock, and cap the sandstone over a very large area. Dykes, sills, and pipes of the dolerite occur in the sandstone, and prove the former to be intrusive. The original dolerite plateaux have been dissected by water action, apparently prior to the faulting which has dislocated the Beacon Sandstone.

IV. *The Ice.* Sea-ice, produced by the freezing of the sea during the Winter, is on an average 8½ feet thick, but during the Summer the sea-water melts the lower surface of the ice. Shore-ice, a fringe of glacier ice attached to the land, shows the conservative action of ice in this latitude. Inland ice, local ice-caps, piedmonts, and other types of glaciers may be recognised in South Victoria Land. The term 'floating piedmont' has been suggested as descriptive of the Great Ice Barrier, or Ice Sheet, of Ross, and there are at least three examples in our area.

The moraines high on the slopes of Mount Erebus, and other moraines stranded at various spots, are considered in their relation to the past and present distribution of the ice, and the conclusion arrived at is that the glaciation is approaching a minimum.

IV.—Evidences of Glacial Conditions in Permo-Carboniferous Times in the Transvaal. By Edward T. Mellor, B.Sc.

[Communicated by permission of the Director of the Geological Survey of the Transvaal.]

THE present paper gives a brief account of recent work in connection with the rocks at the base of the Karroo System in the Transvaal, including some additions to the evidence of extensive glacial action in early Karroo times. The description given of the character and mode of occurrence of the glacial conglomerate is based mainly upon observations made in the course of mapping a district lying between the Elands and Wilge Rivers, east of Pretoria. The Karroo System does not here attain so

complete a development as in the more eastern and southern portions of South Africa. The whole thickness of the formation rarely exceeds 400–500 feet, and it is not possible as yet to recognise the many divisions which it presents in those parts of South Africa where it attains a much greater thickness. Outliers along the margin of the main area occupied by the Karroo System afford good opportunities for the study of the glacial conglomerate which forms its base. They are occasionally entirely composed of this conglomerate owing to the complete denudation of the overlying sandstones and grits.

The upper and well stratified portion of the formation lies everywhere horizontally, and its base maintains a very constant elevation of about 4,900 to 5,000 feet. The glacial beds of the lower portion of the formation rarely show distinct stratification, and outliers consisting of these alone closely resemble, both in appearance and mode of distribution, patches of glacial drift of comparatively recent origin. There is abundant evidence that they were laid down upon an old land surface possessing considerable variety of surface feature, and some of the thickest deposits of glacial conglomerate occur in valleys or below escarpments which were in existence before its deposition.

Owing to the abundant sandy drift arising both from the conglomerate itself and from the grits and sandstones which usually overlie it, the solid conglomerate is rarely exposed at the surface. Where seen, it is of a light yellow or cream colour, and usually consists of a sandy-looking matrix containing abundant boulders and pebbles distributed without definite arrangement through the mass. The pebbles and boulders vary in size from 2 to 3 inches up to as much as 10 feet in diameter. The materials of which the boulders are composed vary much in character. There is always a great preponderance of local rocks, with an admixture of others which can be shown to be derived from comparatively distant sources, which are to the north of the present position of the boulders. In the district here specially referred to, the majority of the boulders consist of hard red quartzites and conglomerates derived from the Waterberg Formation, which underlies the glacial conglomerate over a large part of the area. Almost equally numerous are boulders of the Red Granite, which occurs extensively further to the north.

The boulders are always highly polished and usually facetted. When composed of fine-grained rocks, such as felsites and shales, they frequently show striations on the facets. The matrix of the glacial conglomerate consists of sharply angular fragments of quartz and of rocks similar to those of which the boulders are composed, varying in size from mere grains upwards. It differs to some extent from the matrix of the typical Dwyka conglomerate of the more southern portions of South Africa in presenting an appearance much less suggestive of an igneous origin. By weathering, the matrix of the conglomerate usually gives rise to sandy products; in some localities, however, it produces a yellowish clay, in which the boulders remain embedded. In specimens from a depth, the matrix

is occasionally greenish in colour. Locally there occur in the conglomerate lenticular patches of fine-grained, massive, white or cream-coloured sandstones, and white, finely laminated shales and mudstones.

The progressive denudation of the glacial conglomerate exposes at its margin the glaciated surfaces of the underlying rocks, which frequently show very clear striation. The best examples yet met with are those occurring to the north of the Douglas Colliery near Balmoral. In a number of examples distributed over an area of 300 square miles the striæ exhibit great constancy of direction, and point to the existence of an extensive ice-sheet with a movement from N.N.W. to S.S.E.

It is very probable that the glacial conglomerate extends very much further north than the localities at present known. During the past year outliers of the conglomerate were found ninety miles north of the latitude of Johannesburg.

V.—The Plutonic Rocks and their Relations with the Crystalline Schists and other Formations. By F. P. Mennell.

IT has been pointed out by Teall that the final solution of the problems arising in connection with the origin of igneous magmas is possibly to be looked for where the plutonic rocks are seen in their relations with the crystalline schists. The writer dealt with observations made in such an area and the inferences to be drawn therefrom. He concluded that the average igneous rock has practically the composition of the average granite, and that plutonic rocks are immensely more important than the other classes, even when the term plutonic is used in a much more restricted sense than by many authors. The causes of variation were discussed, and segregation, except as a phenomenon of limited importance, was dismissed as an untenable theory. The origin of the magmas must be considered in order to account for subsequent variation. 'Refusion' seems the only possible mode of formation. Granite appears to result from the effective mixing of the heterogeneous materials melted down, other igneous rocks being the result of the cooling of different parts before mixture is complete, basic material having also the best chance of reaching the surface as lava, owing to its superior liquidity. There is circulation of material between the igneous and sedimentary rocks, the material analysed in the latter being subjected to synthesis in the making of the former.

VI.—Baviaan's Kloof: A Contribution to the Theory of Mountain Folds. By Ernest H. L. Schwarz, A.R.C.S.

BAVIAAN'S KLOOF is a narrow valley lying between mountains belonging to the Triassic period. The geological history may be summarised thus:—

(*a*) First base-level. Deposition of Enon Conglomerate, derived

from the disintegration of the newly-formed mountains, on a plain eroded between the two mountain chains.

(*b*) Period of cross-folding. The area traversed by two sets of folds in directions W.N.W.–E.N.E. and S.W.–N.E.; these let down portions of the surface in deep pits, bounded by circular faults and sharp folds.

(*c*) Second base-level. The Enon Conglomerate removed, except that in the fold-basins, and the surface of the valley again reduced to a double level of erosion.

(*d*) Rising of the land. Deep erosion of the river channels; immense gorges cut in the floor of the plain and most of the loose contents of the Enon Conglomerate in the fold-basins removed.

Cross-folding is the interpretation of the two sets of mountain folds, and the sinking of areas in the meshes between is contrary to what would happen if the folds were produced by direct tangential thrust. The direct thrust theory also has to explain how a force could act at a distance when the material through which it is transmitted is so heavy in proportion to its strength and has such immense friction to overcome.

The resemblance of these Baviaan's Kloof fold-basins to pits found between two sets of crossing ripple-marks has suggested that certain mountain folds are produced by earth-shaking waves which become retarded when approaching an immovable buffer, such as masses of granite anchored to the deep substructure of the earth's crust. This theory is further illustrated experimentally by what happens in a lead sink where hot and cold water is let in at one end from a tap; the disturbance produced by this gradually causes ridges to form at the further end of the sink, though the lead is too pliant to allow a direct thrust thus to act at a distance.

'Shearing' and 'fold arc' structure may also be explained on the wave theory, whereas 'block up-lift' structure is rather a problem in isostasy.

REVIEWS.

I.—An Introduction to Geology. By J. E. Marr, Sc.D., F.R.S. 8vo; pp. viii, 229, with 33 illustrations. (Cambridge: at the University Press, 1905. Price 3*s*.)

WHAT geology flourishes as a recreative science is manifest to all who read their Quarterly Journal, Geological Magazine, or Proceedings of the Geologists' Association; while the good work that is being done and may be done by amateurs as well as professionals, especially in the study of fossils, formed the text last year of Dr. Smith Woodward's interesting address to the Geologists' Association. Most excellent work is being achieved by those who concentrate their attention on certain formations, or fossils, or districts; and it is necessary that the supply of such workers be maintained.

The little book before us, by the President of the Geological Society, is well calculated to promote this object; indeed, it was written as an introduction for those who will subsequently proceed to more advanced treatises and as a guide to those general readers who simply desire to obtain some idea of the science. As far as possible in a limited space the author has provided good and stimulating material for both classes of enquirers, a task always difficult, and if, as will surely be the case, the student finds that the information on this or that point is too meagre, he will, we trust, be induced to turn to other guides and philosophers, if not to the classroom where Dr. Marr has so long and successfully expounded the principles of geology and the methods of research.

The book is illustrated by many diagrams and by several beautiful photographs, notably those of a glacier, glaciated rocks, graptolites, a trilobite, and nummulites.

We are doubtful whether the diagram of fan-structure, fig. 15, p. 93, would be easily intelligible to the student. It rather represents an anticlinorium than the *structure en éventail* where the bands of rock in a doubly inverted anticline spread out in fan-like form, as figured in Sir A. Geikie's Textbook, vol. i (1903), p. 678, or in Chamberlin & Salisbury's Geology, p. 484. In saying this we admit that a figure somewhat similar to that in the book before us was given by Lapworth in his "Secret of the Highlands." Geological Magazine for 1883, Plate V, but we think that the true fan-structure of A. Favre, Heim, and others is represented in Plate VIII, Figs. 6 and 7, accompanying the same article. Such a handy book is certain to be taken up by many readers.

II.—Memoirs of the Geological Survey.

The Geology of Mid-Argyll. By J. B. Hill, R.N., with the collaboration of B. N. Peach, LL.D., F.R.S., C. T. Clough, M.A., and H. Kynaston, B.A. With Petrological Notes by J. J. H. Teall, D.Sc., F.R.S., and J. S. Flett, M.B., D.Sc. pp. vi, 166. (1905. Price 3*s*.)

THE area embraced in this memoir, very lucidly described by Mr. Hill in the Introductory Chapter, extends from the borders of Upper Loch Fyne into the district of Lorne on the north-west and to Cowal on the south-east. The capital of Argyllshire stands near the centre, and there is an excellent photographic frontispiece showing Inveraray Castle and the raised-beach platform that fringes Loch Fyne. A great part of the district is formed of metamorphic schists, including slates, quartzites, schistose grits, and limestones, together with mica schists, graphite schists, and the problematical "Green Beds," which may have originated as clastic rocks derived from basic igneous rocks. Lower Old Red Sandstone and conglomerate with andesites, etc., occur in the north-western region. The most mountainous portion is that in the north-east, on the borders of which the ancient schistose rocks of Beinn Buidhe

rise 3,106 feet. Rather full particulars are given of all the metamorphic and older igneous rocks, the latter comprising epidiorite and serpentine; there is a chapter on the effects of folding and progressive regional metamorphism; while the later intrusive rocks, granite, hyperite, diorite, and kentallenite, various sills and dykes, and the Tertiary intrusions furnish ample material for those interested in petrography. Matter perhaps of more popular interest is contained in the chapter on the Glacial and Recent deposits. It is pointed out that the gathering-ground of the ice-cap, which in the period of maximum glaciation completely overrode this mountainous district, was situated in the Grampian range to the north-east, the ice issuing in a south-westerly direction along the parallel basins of Loch Fyne and Loch Awe; the major rock-basins coincide with the direction of this ice-flow, and the evidence generally obtained in the area favours the connection of the rock-basins with glacial phenomena. Of the various glacial drifts and fluvio-glacial gravels, of the raised beaches and the story they tell of changes of level, and of the economic deposits of the area we find many interesting and useful particulars. A bibliographical list is given in the appendix, but perhaps further references in the text might have been given to the observations of other geologists who have written on Argyllshire.

III.—The Geology of the Country around Cork and Cork Harbour. By G. W. Lamplugh, F.G.S., J. R. Kilroe, A. McHenry, M.R.I.A., H. J. Seymour, B.A., W. B. Wright, B.A., and H. B. Muff, B.A. pp. vii, 135. (1905. Price 3*s*.)

THIS memoir is descriptive of a specially prepared and colour-printed map of the country around the city of Cork, including the whole of Cork Harbour; the area having been re-surveyed with the object only of mapping the glacial drifts and other superficial deposits.

The older geological formations include the Lower and Upper Old Red Sandstone (termed on the previous Geological Survey map the Dingle and Kiltorcan Beds) and the Carboniferous Limestone Series. The boundaries that mark the exposed limits of these older rocks are reproduced from that Survey; and the only notable change is the abolition of the term "Coal-measures?" which strangely enough was used for beds now grouped as "Upper Shale or *Posidonomya Becheri* Beds." So much interest attaches to the relations of these Old Red and Carboniferous beds to the equivalent strata in the west of England and South Wales, that it is a matter of regret that the attention of Mr. Lamplugh and his associates was confined (officially) to the mapping of the superficial deposits. In consequence we have to be content with a good deal of information gathered more than fifty years ago, as the district was surveyed by Jukes and his staff in 1851–2; while the explanatory memoir on Sheets 187, 195, and 196, owing to "the inadequate means afforded us to carry out our work to completion," was not issued until 1864.

Needless to say, there is much of interest in the remarks of Jukes on the Old Red Sandstone, Devonian, and Carboniferous rocks in that old memoir, which deals with a large part of the area described in the work before us.

Until the new survey was carried out our knowledge of the Glacial Drifts of the district was meagre, and the greater part of the present memoir is occupied with a general and detailed description of the raised beaches, 'head,' boulder-clay, glacial sands and gravels, old river gravels and deltas, and other superficial deposits. The story told by these complex accumulations has been most ably and skilfully disentangled; and we commend its perusal to our readers. The pre-glacial or early glacial shore-line discovered by Messrs. Muff & Wright near the mouth of Cork Harbour consists of a rock-shelf, on which there rests in succession raised beach, blown sand, 'head' or talus, boulder-clay, and an upper 'head.' The ancient shore-line is distinctly older than the glaciation of any part of the south or south-east of Ireland. The present river valleys, the origin of which was discussed in a classic paper by Jukes, were mainly of pre-glacial age. The valley system of the interior has been only slightly modified, and the present sea-inlets have been brought about by depression whereby the lower parts of the valleys were submerged. The memoir is well illustrated with photographic plates and other figures, and it contains a useful chapter on economic geology.

IV.—Geological Survey of Canada. By Robert Bell, I.S.O., M.D., F.R.S., Acting Director. Part O, Annual Report, vol. xiv. The Artesian and other Deep Wells on the Island of Montreal. By Frank D. Adams, D.Sc., F.G.S., and Osmond E. Leroy, M.Sc. 8vo; 74 pp. (Ottawa: S. E. Dawson, 1904.)

THE objects kept in view by the authors of this able report were, in the first place, to describe as completely as possible all the borings put down in the Island of Montreal up to the close of the year 1903, and secondly, to ascertain, if possible, whether any definite water-bearing horizons existed in the underlying rocks, and by a study of the geology of the district to learn the character and origin of the subterranean water supplies and the prospect of obtaining water by further borings.

Eighty-nine boreholes were found to have been made during the period covered by the report. Only six of these were, however, actually flowing, that is artesian wells, most of the Montreal wells requiring to be pumped. A tabulated list specifies the depth in feet of the borings, the diameter of the holes in inches, the capacity per diem in gallons (much higher than that usually required), the character of the water, hard, soft, saline, etc., together with the names of the owners, location of the borings, and other details. A careful description of each boring follows this list, from which it is seen that most of the wells yield potable waters, while some of them are hard, owing to the presence of a considerable quantity

of lime or magnesia salts, thus rendering them unsuitable for use in steam boilers. Others, being impregnated with sulphurous compounds, or possessing a saline character, are only of use for cooling purposes. Analyses of the waters have been made from time to time, but these having been prepared merely for technical purposes are in most cases incomplete. A comparative examination of them, however, brings out some interesting points bearing upon their chemical composition in relation to the rocks from which they were derived.

Regarding the course of the underground waters supplying the numerous wells sunk in the thickly-bedded (Ordovician) limestones in the Island of Montreal, the authors conclude that the channels through which the waters flow have the form of irregular fissures, and that "there is no distinct water-bearing horizon in the form of interstratified permeable beds." The proof of this is to be found in the circumstance that both the supply and the character of the water differ in borings in comparatively close proximity to each other. The irregular course of the waters is partly influenced by the presence of abundant dykes and sheets of impervious igneous rocks traversing the limestone strata in every direction.

A very moderate estimate shows that the wells already bored would yield, if pumped to their full capacity, 2,500,000 gallons per diem, which is nearly one-tenth of the daily average pumped by the Montreal Water Works for the use of the city.

The source of the underground water is considered to be in all probability the higher portion of the plains along the flanks of the Laurentian country in the north-western part of the Island of Montreal.

This valuable report is illustrated by diagrams in the text, and by (1) a geologically coloured map of the Island of Montreal and its vicinity, (2) a topographical map of the city of Montreal with the positions of the borings, (3) graphic diagrams showing the relations of certain groups of wells in the city of Montreal and its vicinity.

ARTHUR H. FOORD.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

I.—December 20th, 1905.—J. E. Marr, Sc.D., F.R.S., President, in the Chair. The following communications were read :—

1. "The Highest Silurian Rocks of the Ludlow District." By Miss Gertrude L. Elles, D.Sc., and Miss I. L. Slater, Newnham College, Cambridge. (Communicated by Professor T. McKenny Hughes, M.A., F.R.S., F.G.S.)

After an introduction dealing with previous work in the district, the authoresses adopt the following classification of the beds :—

			Feet.	
III. Temeside Group.	B.	Temeside or *Eurypterus* Shales	110 to 120	Zone of *Lingula cornea* and *Eurypterus*.
	A.	Downton Castle or Yellow Sandstone	30 to 50	Zone of *Lingula minima*.
II. Upper Ludlow Group.	B.	Upper Whiteliffe or *Chonetes* Flags	150 to 160	Zone of *Chonetes striatella*.
	A.	Lower Whiteliffe or *Rhynchonella* Flags	110 to 120	Zone of *Rhynchonella nucula*
I. Aymestry Group.	B.	Mocktree or *Dayia* Shales	40 to 150	Zone of *Dayia navicula*.
	A.	Aymestry or *Conchidium* Limestones	75 to 250	Zone of *Conchidium Knightii*.
			515 to 850	

A brief outline description of the main subdivisions is first given, as they appear when followed from Ludlow southward to Overton, eastward to Caynham Camp, westward to Downton-on-the-Rock, and northward to Bromfield, and also near Onibury and Norton. The main tectonic features of the district appear to be due to the superposition of Armorican movements in rocks with a Caledonian trend, held by some rigid mass to the north, presumably the Longmynd massif. A detailed description is then given of the succession, as seen at the following localities: River Teme, Wigmore Road, Deerhouse Bank, Caynham inlier, the Teme and north-east of the Castle at Downton, Downton Castle inlier, Mocktree, and near Onibury on the Craven Arms Road, the Onibury Norton Lane, and at Norton. The paper closes with a detailed list of fossils obtained by the authoresses, supplemented by the collection in the Ludlow Museum.

2. "The Carboniferous Rocks at Rush (County Dublin)." By Charles Alfred Matley, D.Sc., F.G.S. With an Account of the Faunal Succession and Correlation. By Arthur Vaughan, B.A., D.Sc., F.G.S.

Rocks of the Carboniferous Limestone Series are exposed along 5 miles of coast near Rush, Loughshinny, and Skerries, in county Dublin. The present paper deals only with the beds near Rush, in the southern portion of this tract, where about 2,500 feet of the series are exposed, without allowing for gaps in the succession. The upward sequence is (on the whole) from south to north, and the range is from the Upper *Zaphrentis* to the Upper *Dibunophyllum* Zone.

The Rush Slates are the lowest beds, 1,380 feet thick, but their base is not visible. They consist of black and dark-grey, well-cleaved argillaceous, and less perfectly cleaved calcareous, slates; and they contain bands and nodules of limestone. The peculiar outcrop of some of the limestone bands is described, and instances of cataclastic structure are noticed. The characteristic fossil is *Zaphrentis* aff. *Phillipsii*.

The Rush Conglomerate Group succeeds the Rush Slates, after a short interval of passage-beds. It is 500 feet thick, and consists of well-bedded alternations of conglomeratic, pebbly, and sandy limestones, with shales and calcareous flaggy beds. Ordovician

and Silurian rock-fragments abound in them, together with many inclusions of Carboniferous Limestone. The group is shown to be of the same age as the Pendine *Syringothyris* conglomerate and the volcanic rocks of Weston-super-Mare, and its existence indicates that the movement and disturbance in Mid-Avonian times extended over a considerable area.

The beds above the conglomerates are mainly limestones and calcareous shales. They are thrown into numerous sharp folds, and are occasionally inverted. The highest beds seen (*Cyathaxonia* Beds) are correlated with the Eastern Gower or Oystermouth Limestone of the South-Western Province; but the fauna agrees still more closely, and is identical, with that of the highest Avonian beds of the Midlands of England, at Parkhill, Wetton, Thorpe Cloud, etc. The disappearance by solution of a considerable thickness of limestone is described.

A list is given of the fossils from a large number of horizons in the Rush Series (which is divided into the *Zaphrentis*, *Megastoma*, and *Cyathaxonia* Beds), as well as of the fauna of the Curkeen Hill Limestone, near Loughshinny, the horizon of which is assigned to the Upper *Dibunophyllum* Zone, probably below the *Cyathaxonia* Beds.

The palæontological section deals only with Brachiopods and Corals. In that part which deals with the Brachiopods the interrelationship of the various members of the more important gentes is discussed in considerable detail. In the part which is devoted to the Corals a new subgenus is suggested, and four new species are described.

Professor G. F. Wright, in exhibiting a map of the Lebanon district, gave an interesting description of the evidence which he found, in a recent journey to that district, as to the height and extent of the terminal moraine. He remarked also that the water-level in the Jordan Valley stood, in comparatively recent times, 750 feet higher than at present, and this he connected with the glaciation of the area. Very small climatic changes would be sufficient to start the Lebanon Glacier again.

II.—January 10th, 1906.—J. E. Marr, Sc.D., F.R.S., President, in the Chair. The following communications were read:—

1. "The Clay-with-Flints: its Origin and Distribution." By Alfred John Jukes-Browne, B.A., F.G.S.

Until recently the Clay-with-Flints has been regarded as being, in the main, a residue from the slow solution of the Chalk. This was the explanation proposed by Mr. W. Whitaker in 1864, although he admitted that the deposit included some material derived from the Eocene. Writing in 1865, Mr. T. Codrington thought that an overlying stratum of clay or loam was essential to the formation of Clay-with-Flints. Lastly, Charles Darwin in 1881 seems to have taken it for granted that it was solely a residue

from the Chalk. Of late years the opinion has been growing that it consists very largely of material derived from the Eocene.

The present paper is devoted to an examination of the facts, with the view of ascertaining whether the Clay-with-Flints could possibly be derived from the Chalk, or whether the theory of its derivation from the Eocene is confirmed by more detailed enquiry. The author first describes its composition, noting that unbroken flints are not everywhere abundant, that broken angular flints are common, and green-coated flints are not rare; finally, that if the clay is washed it always yields a residue of sand, composed chiefly of rounded quartz-grains with some of iron-oxide, and both apparently derived from the Eocene sands.

The thickness of the accumulation is next discussed, especially with reference to sheets of it that lie on fairly even floors. In such positions it varies from 2 to 12 feet in depth, and large areas occur where it must have an average depth of 3 or 4 feet. The products resulting from artificial solution of chalk are then considered, and a series of analyses is given, from which the average amount of insoluble residue existing in the four lower zones of the Upper Chalk is deduced. Experiments have been made by Mr. William Hill to determine the related weights of a cubic foot of Upper Chalk and a cubic foot of Clay-with-Flints, in order that allowance might be made for the difference in calculating the quantity of clay which would be left by the solution of a given quantity of chalk. The result shows that 100 cubic feet of the *Micraster coranguinum* Chalk will produce only 1·2 cubic feet of clay, and the solution of the *Marsupites* and *Micraster coranguinum* Zones to the extent of 200 feet over any part of the area would only yield clay enough to make a layer 2 feet deep. Lastly, it is shown that the quantity of flints in the Upper Chalk is so much greater than the quantity of clay that the natural residue could not form a Clay-with-Flints. Thus, solution of 100 feet of *Micraster coranguinum* Chalk would yield a bed of flints about 7 feet thick, and only enough clay to fill up the interstices between the nodules.

The next section is devoted to the distribution of the Clay-with-Flints, and its stratigraphical relations to the Chalk on the one hand and to the Eocene on the other. In dealing with this part of the subject, details are restricted to the areas lying west and north-west of the London Basin and to the wide area between the London and Hampshire Basins.

From these several lines of investigation the author concludes:—(1) That the Clay-with-Flints cannot have been formed from mere solution of the Upper Chalk; (2) that all its components, except the unbroken and angular flints, could have been furnished by the Reading Beds; (3) that the positions occupied by it are such that no great thickness of Chalk can have been destroyed to form it, the tracts being seldom more than 30 or 40 feet below the local plane of the Eocene base, or the presumed level of that plane.

Finally, an attempt is made to explain the manner in which the Clay-with-Flints was formed, and the theory adopted is that the

outlying Eocene tracts, which were in existence during late Pliocene time, were broken up and spread out by the severe climatic conditions of the Glacial Period. In post-Glacial time little has been added, but much removed by erosion.

2. "On Footprints from the Permian of Mansfield (Nottinghamshire)." By George Hickling, B.Sc. (Communicated by Professor W. Boyd Dawkins, D.Sc., F.R.S., F.G.S.)

These fossils were discovered in 1897 by Mr. Francis Holmes in the Rock Valley Quarry, Mansfield, in a local lenticular mass of sandstone intercalated in the Magnesian Limestone. The impressions formed two double rows, approximately parallel, and 7 and 2 feet long respectively. Nearly the whole of the longer series is in the Nottingham Museum, and part of the shorter series in the Manchester Museum. Both sets were made by the same species of animal, the stride in one case being 8 and in the other $8\frac{3}{4}$ inches. The prints show a well-marked heel and comparatively slender digits, and there is evidence of a membrane between the toes. There is wide separation between the right and left sides, this separation being more marked in the fore than in the hinder footprints. The prints present some resemblance to those named *Ichnium acrodactylum*, from the Upper Permian of Thuringia. Recently the author has found other prints in the same quarry.

CORRESPONDENCE.

THE ZONE OF *OSTREA LUNATA*.

Sir,—I am very glad that Mr. Brydone is publishing his further observations on the Chalk bluffs of Trimmingham, and it is clear they will throw valuable light on the much disputed question of the manner in which these masses were brought into their present positions.

I am sorry, however, that he should object to my choice of *Ostrea lunata* as the index-fossil for the zone which his previous observations enabled me to establish on a firm basis; the more so as his reason for objecting to the choice seems to me to have little force. He admits that *O. lunata* "has two characteristics of an ideal name-fossil in that it is, as far as we know, almost confined to the Trimmingham Chalk, and that in that chalk it always occurs abundantly if at all." He thinks, however, that "it fails to fulfil the most important requirement for a good zone-fossil in that it is not distributed all through its so-called zone."

Moreover, Mr. Brydone seems so sure that *O. lunata* will not do as an index that he proposes to rename the beds as the "zone of *Terebratulina gracilis* and *T. Gisei*," in spite of the most obvious objections. I am therefore compelled to defend my choice of a zone-name from his attack upon it.

In the first place I must ask Mr. Brydone why he asserts that the

index-fossil of a zone must be distributed "all through its zone," and what he means by this expression. I am sure that he does not expect to find the chosen fossil in every foot of the chalk which makes up the zone. I suppose, therefore, he means that it ought to occur at frequent intervals throughout the zone, and that the total thickness of beds in which it does occur should be greater than that of those in which it does not.

I greatly wish that fossils would occur in such a well-regulated manner, but unfortunately their behaviour often falls sadly short of what we should like it to be. Mr. Brydone must surely have forgotten that *Marsupites* is not a common fossil throughout the zone of which it is accepted as the index. In fact, it is common only in the *Marsupites* band or subzone, and is rare or absent in the *Uintacrinus* band. Yet I am not aware that anyone has objected to its being used as the index-fossil of the zone, and I sincerely hope that no such objection will ever be taken.

Again, has Mr. Brydone considered the case of the zone of *Act. quadratus*, where that species (as now restricted) only occurs rarely, especially in the higher part of the zone. It is true that Mr. Rowe has proposed to take *Offaster pilula* as the index-fossil, because it is common throughout, but this generally occurs at intervals only, being common in spots or in bands and rare or absent in the intermediate beds, just as *Ostrea lunata* seems to be absent from certain beds in the Trimmingham Chalk.

From the succession of beds given by Mr. Brydone on p. 14 of this Magazine, and assuming his group 3 to be identical with part of his group 4, it is seen that *O. lunata* occurs abundantly at four horizons in the series, and that it occurs in all three divisions. This is quite sufficient to satisfy all reasonable demands on any fossil for qualification as the index of a zone; consequently I must maintain the propriety of my choice, and must object to any other species being substituted for *Ostrea lunata*, unless a much better reason can be given than that advanced by Mr. Brydone.

A. J. Jukes-Browne.

Floriston, Torquay.

DISCOVERY OF *EXOGYRA SINUATA* IN THE LOWER GREENSAND OF CULHAM, NEAR OXFORD.

Sir,—It might interest your readers to hear of the finding of a specimen of *Exogyra sinuata* by Mr. W. D. Hutchinson and myself in the Lower Greensand of Culham, near Oxford.

The specimen is a large one, and was found in a bed of coarse laminated sandstone, in a neighbourhood where the Greensand has been considered unfossiliferous.

Clinton G. E. Dawkins
(Balliol College, Oxford).

6, Larkstone Terrace, Ilfracombe.

OBITUARY.

CHARLES TOOKEY, F.I.C., F.C.S.

BORN MAY 13, 1828. DIED JANUARY 3, 1906.

WE regret to record the death of Charles Tookey. He was born at Oddingley Rectory in Worcestershire, and educated at Bromsgrove School; he became a student at the Royal College of Chemistry in 1851, and was an assistant in the following year. In 1854–5 he was assistant to Dr. Stenhouse at St. Bartholomew's Hospital, and from 1856 to 1865 assistant to Dr. Percy at the Royal School of Mines. During this period he analysed examples of iron-ore from South Staffordshire for part 2 of "The Iron Ores of Great Britain," 1858 (Mem. Geological Survey).

In 1865 he was appointed Assayer in H.M. Mint at Hong Kong, a post which he relinquished in 1868. From 1870 to 1874 he was Assayer, Chemist, Superintendent of Refinery, and Temporary Director at the Japanese Imperial Mint at Osaka. On his return to this country he served 1874–8 as Chemist on the Admiralty Boiler Committee. He was author of papers "On the Separation of Tin from Antimony, and on the analysis of alloys containing Lead, Tin, Antimony, and Copper" (1862) and "On the Manipulation of Assays of Gold and Silver Bullion" (1870), Journ. Chem. Soc.

We are indebted for most of the above particulars to the "Register of the Associates and Old Students of the Royal College of Chemistry, the Royal School of Mines," etc., by T. G. Chambers, 1897.

MISCELLANEOUS.

RETIREMENT OF DR. B. N. PEACH, F.R.S.

IN September last Dr. B. N. Peach, F.R.S., retired from the Geological Survey after a period of 43 years service. Joining the staff in 1862 as assistant geologist, after a distinguished career at the Royal School of Mines, he was engaged for the first few months in determining Carboniferous fossils from the county of Fife under Salter's supervision in the London office. When favourable opportunities presented themselves during his subsequent career, he pursued this branch of research with keen fascination, impelled by the instinct of the naturalist, which he inherited from his gifted father. In the same year he was attached to the field staff in Scotland, then under the direction of Sir Andrew Ramsay, and in 1867 he was appointed geologist when a separate staff was organised for the northern part of the kingdom under the Directorship of Sir A. Geikie. Throughout his long career it has fallen to his lot to take a prominent part in mapping all the Palæozoic formations in Scotland, together with large areas of crystalline schists of the